ON THE MINUTE MEASUREMENTS OF MODERN SCIENCE.

By ALFRED M. MAYER.

Art. I.

I PURPOSE writing a series of articles "On the Minute Measurements of Modern Science." By *minute* measurements I mean the accurate determination of such quantities as lengths from $\frac{1}{100}$th of an inch to $\frac{1}{100000}$th of an inch and less; of durations of time from one second to a few billionths of a second; and of temperatures ranging through a few thousandths of a degree. I speak of these measures as *modern*, because the delicate instruments and refined processes with which we execute them are chiefly the product of the scientific activity of this century. Such measurements are not alone to be looked upon as mere illustrations of ingenuity; far from it, they have important bearings on the industrial progress of our time; for so refined have become the applications of science to the arts that minute measurements are now absolutely required in many operations of national importance, such as in the work required in the great national surveys, in the fabrication and adjustment of the standards of length, weight and coin; in the determination of the velocities of projectiles; in the construction and testing of telegraph lines; in the determination of the strength of materials used in the arts of construction; and in the measurement of the effects of heat in expanding metals and alloys. No greater evidence can be given of the extensive applications of the minute measurements of modern science than the fact that many instruments of precision which a few years ago were only found in the laboratories of a limited number of men of science are now in constant employment in the engineer's shop, in the testing rooms of telegraph lines, and in ordnance laboratories.

It will be my object, in this series of articles, to show, in a popular way, how these measures are made; aiding my words with diagrams of the apparatus, and illustrating the practice of the work by examples drawn from the actual experience of the writer.

The different kinds of minute measurements may be divided into six classes, viz.:

1. Measurement of Length.
2. " " Angles.
3. " " Area.
4. " " Volume.
5. " " Weight.
6. " " Time.

I will touch on these six classes of measurements in order, but will dwell principally on measures of length and of time; selecting from the various classes such examples as afford the best illustrations of the particular processes that I wish to describe. Finally, I shall bring before the reader two remarkable applications of the processes of minute measurements in the solution of two problems. The first is the accurate determination of the lengths of the waves of ether, whose vibrations produce in us the sensations of the different colors; the second refers to the analysis of the nature of the different kinds of electric discharges and to the measurement of the time of duration of these flashes. I have selected these two examples because they will serve to give a clear idea of the refined character of the work done in the laboratories of modern physicists, and also because up to this date the best work done towards the solution of these problems has come from American philosophers.

To persons drilled in mechanical pursuits the manner in which we make the minute measurements of modern science will be readily understood, by reason of the readiness with which they can comprehend all of the combinations of mechanism which go to form our delicate and precise instruments. This class of readers I therefore chiefly address, in the pages of the journal which they have chiefly adopted as their own.

Before beginning the description of any of the methods for measuring lengths we should endeavor to give the reader some definite conceptions as to the size of the magnitudes which we purpose measuring. To reach such conceptions is not easy; indeed the most difficult part of my task will be to give the reader some idea of the magnitudes of the minute quantities which will form the subjects of our study.

If the reader will look at an l on the page he is now reading, he will see a black band, forming the body of the l, which is $\frac{1}{125}$th of an inch in breadth. This I have carefully determined by measures on many ls taken from various numbers of this journal. The reader has thus always before him a definite measure to which he can constantly refer while reading these articles. But $\frac{1}{125}$th of an inch is considered a large quantity in modern measurement. Often has the writer measured to the *thousandth* part of the breadth of the l: that is, to the $\frac{1}{125000}$th of an inch. Indeed, at the present moment of writing, one of my students is engaged in this very operation in my laboratory, in the process of measuring the amounts of expansion which different metals and alloys undergo when heated through known degrees of temperature. It may now surprise the reader when I state that measurements of this minute fraction of an inch are made with as much readiness as that made by a carpenter when he obtains the length of a board; but when he has read the description of the apparatus and the manner of using it, he will be of my opinion. Yet, although we can readily measure such a minute quantity, we cannot so easily form a conception of that which we have measured.

Let us see how far we can approach to it. Select an l on a page of this journal, and with a sharp penknife draw a fine cut in the direction of the line a b, Fig. 1, that is, from the right hand of the base of the rectangle of the l to the left-hand corner of the upper border of the l. Then lop off the projecting piece on the right of the base by a cut in the direction from a to c, and remove this from the paper, as well as the portion a b g of the l. A triangle is thus formed, having for base b c, and for height c a. Since the lines a b and a c diverge from a point a until they enclose the base b c, which is $\frac{1}{125}$th of an inch in length, it is evident that if we slide the clean cut edge of a piece of paper up the l till it reaches d, half-way between c and a, we will then have another triangle formed having a base at d equal to $\frac{1}{250}$th of an inch. When the paper edge reaches e, which is half-way between d and a, the base of the triangle at e, thus formed, will equal $\frac{1}{500}$th of an inch, and when the edge has risen to f, which is half-way between e and a, the base of the triangle at f will equal $\frac{1}{1000}$th of an inch. By sliding the paper edge a very little above the point e, we have a triangle exposed whose base is $\frac{1}{10000}$th of an inch. The above described operations had best be performed by the aid of a magnifying glass, and then the results of the operations viewed by the naked eye, at a distance of ten inches.

The writer has found from several measures that a line of $\frac{1}{1000}$th of an inch in breadth is obtained by drawing the finest line possible on Bristol board with a sharply pointed H H H lead pencil.

But a thousandth of an inch is one hundred times as long as what we desire to form a conception of. In other words, $\frac{1}{1000}$th of an inch is to $\frac{1}{100000}$th of an inch as 100 inches is to one inch. If the reader will divide 8 feet 4 inches into inches, and look attentively at one of these inches and compare its length to the 8 feet 4 inches, he will have grasped the relative magnitude of $\frac{1}{100000}$th of an inch and $\frac{1}{1000}$th of an inch. What he has obtained by this comparison is, however, only a conception of relative magnitudes, and really does not give the reader a definite idea of the real length of $\frac{1}{100000}$th of an inch.

To approach to the conception of a minute magnitude smaller than any we can possibly see, we must first have before the eye the smallest magnitude visible by unaided vision; and secondly, we must mentally subdivide this quantity to the extreme limit that the mind is capable of.

Let us perform the first part of this process and determine for ourselves the dimension of the smallest magnitude visible by the unassisted eye. At the outset it is necessary to explain that in the determination of this magnitude the eye must be placed at a certain fixed distance from the object. This distance is 10 inches, which is the distance universally adopted as that of most distinct vision. It is evident that the eye must be at a definite distance from the magnitude, for the latter will appear larger or smaller as the eye approaches to or recedes from it. This fact is very neatly shown by the following experiment. Take two pieces of white drawing paper, with clean cut straight sides; on one of these draw, in very black india ink, a disk of $\frac{1}{8}$th of an inch in diameter. On the other piece of paper draw another black disk of three times the diameter of the first disk: that is, of $\frac{3}{8}$ths of an inch. Place before you the piece of paper having on it the disk of $\frac{1}{8}$th of an inch and regard it with only one eye. By vision with one eye you cannot judge of the distance of the plane of the paper from the eye. This you can prove for yourself by suspending the paper in the centre of a room, and with only one eye open endeavor to bring the tip of the finger, with a side motion, to touch the vertical edge of the paper. You will find it almost impossible, till after many trials, to point out with your finger the position of the sheet of paper. This having been understood, let an assistant arrange the papers so that one is behind the other, but so that both black disks are visible. While this adjustment is going on, let the observer have his back to the papers. Now turn round, and with only one eye open regard the disks. If properly lighted, they will appear as drawn on one piece of paper, and of different relative sizes, according to the distances of the papers from the eye. If both, for example, appear of the same diameter, it will be found on measurement that the larger disk is farther from the eye than the smaller by just as much as the former is greater in diameter than the latter. But if they appear of different sizes, it is impossible to predict which of the disks is the one nearer the eye; for, if the smaller disk is six times nearer the eye than the larger, then it will appear twice as large as the latter, although in reality it is three times smaller.

The following is a curious and easily repeated experiment, showing that the apparent magnitude of a body depends upon its distance from the eye. Perforate a card with a pin, and through the hole regard the black disk of $\frac{1}{8}$th of an inch in diameter. It will be found that the eye thus placed can be brought quite close to the disk, even to a half inch from it, and yet the disk will appear quite sharp in outline, and so magnified that it appears to fill the entire hole in the card. Now, as the distance of the perforated card and of the eye from the disk is increased, the latter appears to shrink in size, until even ten or twenty disks, placed side by side, would appear just to stretch across the hole in the card. These experiments are simple and readily made, and should be repeated by those who would clearly apprehend what now follows, viz.: Experiments to determine the dimension of the smallest black disk on a white ground which is visible to the naked eye at the distance of ten inches.

I drew black disks of various diameters from $\frac{1}{10}$th to $\frac{1}{5}$ths of an inch in diameter on the whitest drawing paper, and successively placed these papers in the bright sunshine. With the sun at my back, I withdrew to such a distance from the paper that the disk just disappeared from view, or at least only appeared fitfully, as it were by flashes. Similar experiments were made on all of the disks, and these experiments were repeated by different observers. By dividing the distance from the paper at which the disk disappeared from sight by ten inches, gives a quotient by which we divide the real diameter of the disk, and the result of this last division is the diameter of the smallest black disk on a white ground, which is visible to the naked eye at a distance of ten inches. The result of these experiments showed that the diameter of the smallest visible black disk is about $\frac{1}{200}$th of an inch.

In an actual experiment we had a disk of $\frac{44}{100}$ths of an inch in diameter, which disappeared from our vision at a distance of 90 feet. Ninety feet, or 1,080 inches, divided by 10 inches, gives 108; and $\frac{44}{100}$ths of an inch, divided by 108, gives $\frac{1}{244}$ of an inch as the diameter of the smallest visible disk.

A line of far less breadth than $\frac{1}{200}$th of an inch can be distinctly seen, for in this case not only is the image of the breadth of the line depicted on the retina of the eye, but also the image of its length. From actual experiment I have found that I could just see a line of $\frac{1}{500}$th of an inch in breadth, when this line was a black one on a dull silver surface.

We have now reached definite numbers as to the limit of the visibility of the minute, viz.: a disk of $\frac{1}{200}$th of an inch in diameter, and a line of about $\frac{1}{500}$th of an inch in breadth; and we are now ready to take the second step in the attempt to reach the most minute quantity that we can form a definite conception of. The question now before us is this: Can we mentally divide these magnitudes which lie on the border between the visible and the invisible, and form to ourselves clear pictures of their fractional parts? Evidently the furthest subdivision by the imagination of the smallest visible magnitude depends on our power of being able to form a conception of the smallest visible magnitude as divided into the greatest number of equal parts that the imagination can simultaneously grasp, and then on our power of viewing one of these parts alone. At first sight, this process will bring us to the extreme limit of our definite conceptions of minute quantities. Here then we are brought to the necessity of testing for ourselves how far we can mentally subdivide a length into equal fractional parts, or, what comes to the same thing, we must test our powers as to the number of similar units we can see at one and the same time. All of us can mentally subdivide a line into two equal parts and into three equal parts, and further, into four equal parts. Here ends my own power of seeing at one and the same time the fractional parts of the unit. Some say that they can simultaneously see five fractional parts. For myself, I can only picture the latter division by seeing the fractional parts of the unit as divided into two groups—one containing three fractional parts and the other group, contiguous to it, and containing two fractional parts. The division of the unit into six parts I can effect only by viewing two groups formed of three and three, or of four and two fractional parts. In like manner, the seventh of a unit is obtained by the subdivision of the unit into two groups of four and three fractional parts. The eighth is obtained by viewing the unit as divided into two groups containing each four fractional parts, or into three groups containing respectively three, three, and two fractional parts. The one ninth is reached by seeing the unit divided into three parts, and each of these parts subdivided into three parts. And in a similar manner I have succeeded with more or less difficulty in mentally subdividing a unit into ten, eleven, and twelve fractional parts. Here end my powers of mentally breaking up a unit into equal fractional parts. If our powers of numerical conception are bounded by the number twelve, how contracted are they when compared with the unlimited scope of the modern mathematics. To follow the closely connected logical steps by which we obtain a measure or reach a numerical result is generally quite easy, but it is often difficult, and generally impossible, to form a conception of the numbers which are the results of these measures.

This subject of numerical conception is so very curious that the reader will read with interest the following abstract from an article written (in *Nature*, February, 1871) by Prof. W. S. Jevons, of Owens College, Manchester, England, in which he gives his own experience in similar mental operations:

"It is well known that the mind is unable through the eye to estimate any large number of objects without counting them successively. A small number—for instance, three or four—it can certainly comprehend and count by an instantaneous and apparently single act of mental attention. The limits of this power have been the subject of speculation or experiment among psychologists, and Sir William Hamilton thus sums up almost the whole of what is known about it:

"'Supposing that the mind is not limited to the simultaneous consideration of a single object, a question arises, How many objects can it embrace at once ? * * * I find this problem stated and differently answered by different philosophers, and apparently without a knowledge of each other. By Charles Bonnet, the mind is allowed to have a distinct notion of six objects at once; by Abraham Tucker, the number is limited to four; while Destutt Tracy again amplifies it to six. The opinion of the first and last of these philosophers appears to me correct. You can easily make the experiment for yourselves, but you must beware of grouping the objects into classes. If you throw a handful of marbles on the floor, you will find it difficult to view at once more than six, or seven at most, without confusion; but if you group them into twos, or threes, or fives, you can comprehend as many groups as you can units, because the mind considers these groups only as units; it views them as wholes, and throws their parts out of consideration. You may perform the experiment also by an act of imagination.'

"This subject seemed to me worthy of a more systematic investigation, and it is one of the very few points in psy-

chology which can, as far as we yet see, be submitted to experiment. I have not found it possible to decide conclusively in the manner Hamilton suggests, whether four, or five, or six is the limit, nor do imaginative acts of experiment seem likely to advance exact knowledge. Probably the limit is not really a definite one, and it is almost sure to vary somewhat in different individuals. .

"I have investigated the power in my own case in the following manner: A round paper box 4½ inches in diameter, lined with white paper, and with the edges cut down so as to stand only ½ inch high, was placed in the middle of a black tray. A quantity of uniform black beans was then obtained, and a number of them being taken up casually were thrown towards the box, so that a wholly uncertain number fell into it. At the very instant when the beans came to rest, their number was estimated without the least hesitation, and then recorded with the real number obtained by deliberate counting. The whole value of the experiment turns upon the rapidity of the estimation; for if we can really count five or six by a single mental act, we ought to be able to do it unerringly at the first momentary glance.

"Excluding a few trials which were consciously bad, and some in which the number of beans was more than 15, I made altogether 1,027 trials, and the following table contains the complete results:

ESTIMATED NUMBERS.	ACTUAL NUMBERS.												
	3	4	5	6	7	8	9	10	11	12	13	14	15
3	23												
4		65											
5			102	7									
6			4	120	18								
7			1	20	113	30	2						
8					25	76	24	6	1				
9						28	76	37	11	1			
10						1	18	46	19	4			
11							2	16	26	17	7	2	
12								2	12	19	11	3	2
13										3	6	3	1
14										1	1	4	6
15											1	2	2
Totals...	23	65	107	147	156	135	122	107	69	43	26	14	11

"The above table gives the number of trials in which each real number was correctly or incorrectly guessed; thus, in 120 cases 6 was correctly guessed; in 7 cases it was mistaken for 5, and in 20 for 7. So far as my trials went, there was absolute freedom from error in the numbers 3 and 4, as might have been expected; but I was surprised to find that several times I fell into error as regards 5, which was wrongly guessed in 5 per cent. of the cases. Abraham Tucker thus appears more correct as to my power than the other philosophers."

We have seen that the unaided eye cannot see a disk smaller than 〈1/30〉th of an inch in diameter; and even allowing that we can form a conception of a magnitude smaller than any we can see, yet our power of forming a clear conception of the minute must find its limit in a magnitude about 〈1/10〉th the diameter of the smallest visible object. How limited then are our powers of comprehending the numerical results of the measurements made with the precise instruments of modern science. Yet we feel sure of our results, although conceptions of the magnitudes measured are beyond our mental grasp; for, on introducing these measurements into our mathematical calculations, we reach new results, which are confirmed by subsequent actual experiments; and furthermore, those who take the facts discovered by our minute measurements and use them in practical applications in the arts, find that they bring about results which do not cause loss of money; for, after all said, one good test of the truth of a supposed discovery of a law of nature is that, when we follow its guidance in practical matters, we find that it does not cause us to waste our time and our money.

ASTRONOMY.

Scintillation of the Stars.—M. Montigny has continued his researches on this subject with especial reference to the influence of the approach of rain on the twinkling of the stars. Eighteen hundred observations referring to seventy stars have been discussed, two hundred and thirty nights having been devoted to this work with the scintillometer, already described in these columns. The conclusions at which M. Montigny arrives are as follows: 1. At all times of the year the scintillation is more marked under the influence of rain. 2. Under all circumstances it is more marked in winter than in summer, and also in spring than in autumn for wet weather: in dry weather the spring and autumn are nearly equal in this respect. 3. Scintillation varies with the atmospheric refraction. 4. The approach of rain, and especially its continuance, affect the intensity of scintillation. 5. The amount of rain is always greater on the second of two days than on the first, but it is less in winter than in summer, and the more marked scintillation in winter results, therefore, from the increased density of the air due to the low temperature and high barometer. Similar conclusions are arrived at by grouping together the observations according to the intensity of scintillation, eighty-six per cent. of the days with very marked scintillation being under the influence of rain. The twinkling of the stars appears also to be very marked in windy weather, and strong scintillation is a sign of an approaching storm, the colors being more decided in the case of rain, and accompanied by irregularities in the image. It is to be remarked that this is the case notwithstanding the fall in the barometer corresponding to a decrease in the density of the air, which would naturally diminish the scintillation. As might be expected, the altitude at which twinkling first becomes sensible is increased by the approach of rain.

The Variations of Gravity.—The pendulum observations made in India have shown that there is a deficiency of attracting matter under that great continent, and this conclusion is borne out by a comparison of the geodetic and astronomical longitudes of stations on the east and west coast, from which it appears that the ocean bed exercises a stronger attraction than the raised land. In the *Astronomische Nachrichten* Herr Hann calls attention to this, and also to the circumstance that oceanic islands show an excess of attraction which cannot be accounted for by the nature of the rock of which they are composed. The theory that there are great cavities under the large continents appears hardly tenable, and the more probable supposition would seem to be that they rise above the sea-level by virtue of their specific lightness, floating perhaps like icebergs surrounded by a floe, with the molten liquid under a thin crust. There are, however, difficulties connected with precession and nutation and tides in a fluid interior, all of which Sir W. Thomson has pointed out, and we can only wait for further data. The balance of evidence, however, seems now to have changed, inclining to the hypothesis of a moderately thin crust with fluid or semi-fluid interior.

The Transit of Venus, 1882.—Prof. Bruhns has calculated the circumstances of this phenomenon, taking Leverrier's tables of the sun and Venus as the basis of his computations. This transit will be visible in England, but the best stations for determination of the parallax will be in America, and in the islands of the Southern Ocean. The experience gained in 1874 will be invaluable for these observations, for which it is to be be hoped that all nations will again join in fitting out expeditions. In preparation for this, Prof. Bruhns has done good service in calculating from the best tables the circumstances of the transit.

Meteors.—For the last thirty-five years Herr Schmidt has kept a systematic watch for meteors at all times of the year, and has collected the results into a catalogue which, when published, will occupy 280 pages in quarto. An abstract of the results obtained is given by him in the *Astronomische Nachrichten*, the most important conclusions being with reference to the hourly frequency of meteors observed. After reducing the observers who took part in the work to one standard—which is absolutely necessary, since it appears that while one of the five would observe 117 meteors, another would only notice 60—the hourly frequency is tabulated for different hours of the night, and for different months, and also throughout the July-August period for each day. From these tables it appears that the average number of meteors per hour is ten, and that the maximum frequency occurs about 3 A. M.; also, leaving out of account the two extraordinary November showers, the maximum of the whole year falls in August (when we pass through the well known stream of Perseids), and the minimum in February. From January to the beginning of July the hourly number remains at about seven, increases rapidly to twenty in August, falls again in September, and then in the three following months increases to about double the number in the first six months of the year. In July and August there are several well marked maxima, the hourly number for the whole series of years, on August 10 in particular, rising to 80 at 3 A. M. This number varies greatly in different years, the greatest displays having occurred in 1863 and 1867, in the former of which years 168 meteors were counted during a single hour. Other observers have recorded still larger numbers, but they bear no comparison to those noted in the two November showers, 2,052 meteors having been counted in one hour on November 13, 1866, and 2,777 on November 27, 1872, when we were supposed to have passed through the tail of Biela's comet. In order to get further information on changes in meteor streams, the meteors which come from definite radiant points, in contradistinction to the sporadic meteors, have been discussed with reference to the number of radiant points above the horizon, and the results support the above conclusions, the meteors coming from each radiant being more frequent in the latter half of the year, and in the early morning hours. The brightness of the individual meteors seems also to increase with their frequency, and this is particularly noticeable in the November stream of Leonids. Herr Schmidt has also noted carefully the color of meteors, and connected it with the average duration of visibility. As might be expected, the white meteors, for which the combustion is more intense and the velocity probably greater, remain visible for a shorter time than any others—namely, three quarters of a second—next to them come the yellow and then the red, the green having the longest duration of all —namely, two seconds.

Change of Color in Stars.—Dr. Klein has for several years remarked a periodical change in the color of *a* Ursæ Majoris, and his observations have lately been confirmed by Herr Weber, who finds that it changes from yellow to fiery red in a period of thirty-five days. If these variations are regular the star should appear of a fiery red about December 19, and it is to be hoped that it will be carefully watched for a week or more before or after this epoch. Unfortunately it is very difficult to get rid of subjective effects in such cases, especially if there is any preconceived idea of the color to be expected; but with a number of observers there is some prospect of being able to eliminate disturbing causes.

The Effect of Sun-spots on Climate.—In the November number of the *Monthly Notices*, a paper by Prof. Langley on this vexed question is published, in which the author deduces from the observations he has for the last few years been making on the radiation from the umbra and penumbra of a spot, what proportion of the sun's heat would be lost by reason of the increased area of sun-spots at a time of maximum, and what would be the consequent diminution in the mean temperature of our globe from this cause alone. After many difficulties Prof. Langley has succeeded in determining the radiation of the umbra of a spot to be about 54 per cent, or a little more than half, of that from the surrounding photosphere, while that from the penumbra is 80 per cent, or four fifths. Thus the spots would appear to radiate a very large amount of heat, though by contrast with the phosphere they appear quite black to the eye. Further, the mean spot area in the year of maximum appears to be, from the observations of Schwabe, Carrington, and De La Rue, about fourteen ten-thousandths of the visible disk, and in a year of minimum somewhat less than one ten-thousandth, while the proportion of umbra to penumbra is about two to five. From these data it would follow that the greatest admissible direct effect of sun spots is to diminish the heat we receive from the sun by nearly one thousandth part. The next question is to find how much of the earth's temperature is due to the sun, and this is a difficult matter, though Prof. Langley is able to fix the limits within which the amount must lie, by considering that the temperature of the earth's surface would certainly fall as low as any which has been observed in the Arctic regions—namely, —56° Centigrade if the sun's heat were altogether withdrawn and could not possibly fall lower than the absolute zero, or —274° Centigrade. Thus, taking the mean temperature of our globe at from + 14 to + 16° C., not less than 70° of this is due to the sun, and not more than 200°. It therefore results that the direct effect of sun-spots in a year of maximum would diminish the mean temperature by not less than two thirtieths, nor more than three tenths of a degree Centigrade. Prof. Langley, of course, does not here deal with a possible indirect effect, or rather accompaniment, of sun-spots in an increase of the solar activity, which might cause a considerable rise of temperature by virtue of increased radiation from the photosphere.

Recent Spectroscopic Results.—Dr. Huggins has made an important advance by his successful application of photography to the spectra of stars, of which he gives an account in a communication to the Royal Society. Although he has up to the present confined his attention to the bright star Vega, which has a well marked spectrum, and is therefore specially adapted to the purpose, there can be little question that he will before long obtain good photographs of the spectra of other bright stars, which will add greatly to our knowledge of their constitution by enabling us to examine the invisible part of their spectra in the ultra-violet, besides giving means for more accurate determination of the position of the lines than is ordinarily possible. There is one great advantage which photography has over the human eye—namely, the length of time during which the effect produced by the luminous body accumulates, a circumstance which makes up for the inferior sensitiveness of the photographic film, and it is by taking advantage of this and giving an exposure of several hours that Dr. Huggins has obtained such good results. His photographs of the spectrum of Vega appear to be capable of very accurate measurement, and, independently of their immediate value, which is sufficiently great, will doubtless prove most valuable records of the present physical condition of this star, in case changes of temperature or other causes should in course of time give rise to changes in the breadth of the strong lines in the spectrum, which extend from G to N. In course of time we may hope for most valuable results from the application of photography to variable stars, though, unfortunately, too many of these interesting objects are exceedingly faint.

The spectroscopic results obtained at Greenwich and given in the *Monthly Notices* include observations of the approach or recession of stars in continuation of former results, as well as measures of displacement of lines in the spectrum of Venus due to its approach and recession before and after conjunction, and of the relative shift of spectral lines at the east and west limbs of the sun and Jupiter, due to the rotation of those bodies, the object being to verify in cases of undoubted and well determined motions Doppler's principle of displacement of lines in the spectrum caused by the motion of the body, on which some doubt has been cast by certain physicists. The results in each case were found to agree remarkably with the known motion, though for the observation of the sun's rotation special precautions had to be adopted to guard against the disturbing effect of the solar heat on the slit of the spectroscope, a circumstance which has given much trouble to former observers, and has afforded ground for refusing to accept their results. With a similar object in view, Prof. C. A. Young, in America, has also, quite lately, made spectroscopic determinations of the sun's rotation, using a very fine diffraction grating given to him by Mr. Rutherfurd, and has obtained a motion slightly exceeding that inferred from observations of sun spots. From this result he is inclined to conclude that the solar chromosphere is really moving more rapidly than the spots, but the value found at Greenwich, which is in remarkable agreement with the received equatorial velocity, would tend to negative this idea. At any rate, further observations with improved methods would be necessary to establish such a point.—*The Academy.*

METEORIC STONES.

IN 1872 an aërolite weighing 25 lb. fell in the neighborhood of Pirna, Saxony. This stone, which is a solid mass of soft malleable iron, with an oxidized surface of a darkish brown color, has, like many other such meteors; diminished in size and weight, partly by the crumbling off of the oxidized exterior, and partly by deliquescence into a reddish fluid. This meteoric stone, when first discovered, contained 93·04 per cent iron, 6·16 of nickel, and 0·23 of phosphorus. Neither manganese, cobalt, nor carbon were to be detected. In the iron itself were wedged little crystals of sulphide of iron, and an analysis proved that there were 37·36 per cent of sulphur contained in them. These crystals, composed of iron and sulphur, form the most peculiar feature of this meteoric stone, but are unfortunately not to be measured, as they present a smooth, glassy surface. The humidity which oozes out of the stone in tiny drops, in some places more than others, is acid to test paper, and chloride of iron is easily discernible in it; indeed, chlorine is, as the analysis proved, diffused through the whole stone. The chloride of iron attracts moisture, and then decomposes the iron itself, and gradually oozes out in the shape of a brownish fluid.

MUSICAL SOUNDS.

AT a recent meeting of the Musical Association, London, G. A. Osborne, Esq., in the chair, Mr. Alex. J. Ellis read a paper on "The Sensitiveness of the Ear to Pitch and Change of Pitch in Music." The first part of the paper consisted of an explanation of a graphic method of representing the division of an Octave into thousandths of a semitone, by means of a diagram containing twelve lines, drawn one below the other, each forty inches long, and each representing a semitone, so that the whole represented a gigantic keyboard of a piano with forty feet for each octave, and strings to every twenty-fifth part of an inch. If only divided into hundredths of a semitone, such an instrument would have 14,400 strings in twelve octaves, and 480 feet long. It then formed a magnified representation of the apparatus in the internal ear, consisting of 16,400 fibers, by the sympathetic vibration of which we recognize sound. Sensitiveness consists, therefore, in the degree of accuracy with which we can localize the fiber set in vibration. The remainder of the paper was devoted to giving an account of the results arrived at by Dr. W. Preyer, Professor of Physiology at Jena, for estimating the interval between two sounds struck successively, and to expressing them graphically by the arrangement explained. The sensitiveness is the greater the smaller the interval recognized or not recognized. The first question was, Are the tones different? The second, If so, which is the sharper? The third, What interval do they approach? The fourth, If they differ from any named interval is the second tone too sharp or too flat? With regard to Unisons, no ear, however acute, that Dr. Preyer had tried in numerous examples could recognize a difference of one-fifth of a complete vibration at any part of the scale, although this represents very different intervals in different octaves. Below 40 vib. a whole vibration was often unheard; above 2,000, the ear was entirely uncertain and mixed all the intervals together. A good ear for Unisons distinguishes one-tenth of a semitone at 64 vib., and gradually less on ascending; eight-hundredths at 128 vib.; one-hundredth at 512 vib.; with a little more in the octave below, and a little less in the octave above. The error in the Octave and Fifth seems more easily detected than in the Unison. Dr. Preyer's experiments referred chiefly to other intervals within the Octave 128 to 256 vib. For the Fourth, an error of the tenth of a semitone was not perceived; for the major Sixth and major Third (which were nearly equal) errors of a very trifle more, as eleven or twelve hundredths were not recognized. But for the minor Third and minor Sixth, as many as seventeen or eighteen hundredths of a semitone could not be detected. For the major Tone errors exceeding four

hundredths of a semitone were discovered. In concluding a very elaborate paper, illustrated by many tables, Mr. Ellis defined a good ear for music in its melodic relations as one which within the distance 64 to 1,024 vib. appreciates an error of one or two hundredths of a semitone in Unisons, Octaves, and Fifths, and can tell its direction, and can appreciate the errors of equal temperament for all other intervals, except perhaps the major Seventh, for which the ear is spoiled by the habit of taking the leading tone much too sharp with the voice and on the violin. The discussion which ensued turned chiefly on the power of absolute pitch (possessed by Dr. Stainer and Mr. Stephens in a high degree), and the determination of the difference of the pitch of two forks, very nearly alike, but with different character of tone. Dr. Stone considered that the results given by the lecturer disproved absolute pitch in any mathematical sense. The difference of standard-pitch shown by the forks also disproved that there was any such thing as an absolute C, for example. As respects the inability to hear a low note, Dr. Stone imagined that a deep tone might be created in the ear as a kind of differential tone. Dr. Stainer explained that of course a wide margin must be given to the statement of absolute pitch. If a tone was called A, it was nearer A than anything else. Mr. Cummings stated that when out of health he heard out of tune, and hence sang out of tune. He mentioned the case of a person who heard a semitone higher on one side of his head than on the other, and also the case of a child under eight years old, who can tell what note is struck on a piano in the next room. Mr. Stephens said that it was the possession of this power in him as a child which determined his musical career. Mr. Verrinder illustrated the difficulty of getting organs tuned to a fork, by an organbuilder having simply laid aside and lost Sir George Smart's fork left for that purpose, so little attention did he pay to such a request.—*Academy.*

SOCIETY OF TELEGRAPH ENGINEERS.

Mr. C. V. WALKER, F.R.S., the President, in the chair. London, November.

THERMO-ELECTRIC BATTERIES.

THE adjourned discussion on Mr. Latimer Clark's paper on "Thermo-electric Batteries," was resumed by the author, who took advantage of the opportunity to explain certain improvements which had been introduced in the manufacture of these batteries, since his paper was read, by Messrs. Cecil and Leonard Wray, Junrs. These improvements claimed an advantage over the form produced by M. Clamond; 1, in the castings of the bars; 2, in the method of building up the batteries so as to reduce the weight and strains upon the lower plates; 3, in the heating arrangements; 4, in the regulation of the draught; and 5, in the arrangement of the coke furnace by which the bars could be removed without the withdrawal of the entire fire.

With regard to the bars the alloy employed is the same, or nearly so, as that employed by Clamond, viz., for the negative metal, two parts of antimony to one of zinc, whilst for the positive sheet iron is used. Messrs. Wray overcame, to a very great extent, the brittleness, or rather the liability to break when touched, of the alloy, by elongating the tongue of the sheet iron, which is thus made to extend a distance of about two-thirds of the entire length of the bar. The positive metal thus extended is placed in a mould, in which the alloy is cast under pressure. The effect is to heighten the breaking strain, to increase the electro-motive force, and decrease the internal resistance. Hitherto the bars which compose the battery have been built up, one row upon the other, by means of a paste or cement; thus each successive row of bars or elements increased the weight of that beneath it, and from this cause the elements frequently became severed. Messrs. Wray meet this in a very judicious manner by giving to each row of elements an independent support. It is, however, in the heating arrangements that their improvements are most conspicuous. The power of this form of battery depends upon the subjection of the elements which compose it, at certain points, to temperatures of as opposite a character as possible; thus one end of the bars has to be subjected to as intense a heat as they can sustain, and the other end to as intensely cold an atmosphere as can be produced. Various have been the means adopted to produce a pile which should stand the intense heat, and the action of the gases forming the products of combination of whatever is employed to heat the pile, but hitherto they have been unsuccessful. Messrs. Wray propose to reduce, if not entirely to obviate, this by employing an earthenware cylinder between the bars of the pile and the chimney heated by the flame. By regulating the flow of air and the draught they are also able to keep under control the heating and cooling process, so as to make it more gradual and to no other. On the whole the improvements suggested by Messrs. Wray are of a very practical character, and are highly spoken of.

NEW LIGHTNING PROTECTOR.

A paper was also read by Mr. Andrew Jamieson on a new form of "Lightning Protector," for submarine cables, etc. The idea, which has been very prettily perfected, has nothing electrically new in it, but it is, nevertheless, mechanically a vast improvement on the means at present adopted for the protection of cables, which has usually consisted of plate protectors, vacuum tubes, and very fine platinum wire. These are usually so arranged that the atmospheric charge entering from the open line wire shall pass through the plate protector first, then the small platinum wire, and finally through the vacuum. The probability is that the intensity of the charge would be carried off at the first-named protector; but failing this, if of such power to do injury to the cable, it would so heat the fine platinum wire as to fuse it, and thus the line would become interrupted until an officer was sent to replace the melted wire, and as this is usually at the shore end of the cable, it not unfrequently occupies some time to do so. Mr. Jamieson connects his open wire to a corrugated barrel within a corrugated cylinder, the corrugations intersecting each other, and so forming innumerable points by which the intensity of the atmospheric charge may be carried off. He then connects the barrel of what may be regarded—having reference to previous arrangements—the plate protector, to a spring which normally rests against a small pillar, and which is in connection with another spring similarly arranged. Each of these springs is withheld from touching the pillar in question by a piece of fine platinum wire attached to its end, the other end of the piece of wire being connected with the cable. The result is that supposing a charge to have passed through the barrel, it will pass into the first-named piece of platinum wire, which it will fuse, and the tension of the spring having been thus removed it will fly back to its pillar of rest, and by this means bring into circuit the second piece of platinum wire. Thus the cable is saved from interruption and still protected, the lineman's journey to the cable

hut is saved, and if necessary the arrangement may be repeated *ad libitum.* The discussion was carried over for the next meeting.

ELECTRO-CHEMICAL DEPOSITS OF ALUMINIUM, MAGNESIUM, CADMIUM, BISMUTH, ANTIMONY, AND PALLADIUM.

M. A. BERTRAND.

THE author has obtained deposits of aluminium on decomposing with a strong battery a solution of the double chloride of aluminium and ammonium. A plate of copper, forming the negative pole, whitens gradually, and becomes covered with a layer of aluminium, which takes a brilliant polish under the burnisher. The double chloride of magnesium and ammonium in an aqueous solution is readily decomposed by the battery, giving in a few minutes strongly adherent and homogeneous deposits of magnesium upon a sheet of copper. It polishes readily. The battery must be powerful. Cadmium is best deposited from the bromide to which a little sulphuric acid has been added. It is then very coherent and very white, and takes a fine polish. The sulphate, if acidulated, also gives an immediate deposit of metallic cadmium, very adhesive, and capable of a fine polish. Bismuth is deposited from a solution of the double chloride of bismuth and ammonium upon copper or brass by the current from a Bunsen element. It is very adhesive; though mat, it is capable of taking a fine polish, and may be introduced in the decoration of objects of art. Antimony can be deposited from a solution of the double chloride of antimony and ammonium at common temperatures. It frequently serves to replace platinum black in a number of fine art manufactures. Deposits of palladium are obtained with ease by means of the double chloride of palladium and ammonium, either with or without the battery. The solution must be perfectly neutral.

NEW DYNAMO-MAGNETIC PHENOMENON.

MM. TREVE and DURASSIER.

LET there be a horse-shoe magnet, of any length, covered upon one side with varnish, or, better, with a plate of glass. If there is 'aid upon the neutral part a cylinder of soft iron, it is seen to move towards the poles, which it reaches in a time which is a function of the weight of the cylinder and of the coercitive force of the magnet. Hence there results a new method of estimating the magnetic force by the mechanical work which it effects.

ELECTRICAL LIFE TEST.

IT is a well known fact that muscles contract under the influence of electricity, and it is long since experiments were first made in the stimulation of dead bodies by this means. Some curious phenomena have been obtained in this way. Recently, Dr. Kappeler, of the hospital of Münsterlingen, has added some new observations on the subject. He subjected twenty corpses to the action of various electric currents, and noted the rate of disappearance of the electric muscular contractility. In persons emaciated by long chronic maladies, this disappeared much more rapidly than in robust individuals, or those who had had acute maladies. It disappeared five quarters of an hour after death, at the quickest, and six and a half hours at the slowest. It is in cases where a rise of temperature is observed after death (which are not extremely rare), that the electric contractility persists longest. The importance of this sign of death is evident if we reflect that the contractions under electricity continue intact so long as there remains the least life. In the most prolonged faints, in the deepest lethargies, in all the varieties of apparent death, poisonings by carbonic oxide, chloroform, or narcotic substances, this valuable sign can be had at will, so long as real death is not a *fait accompli.* The fact of death, too, can be thus ascertained without the necessity of awaiting other certain signs of death. Some interesting cases in this connection are related by Dr. Kappeler in his paper, which appears in the *Bibliothèque Universelle* for November.—*Telegraphic Journal.*

TELEGRAPHIC FAC-SIMILE TAPE.

L. YOUNG, of New York city, has invented a new tape, as follows:

Instead of paper, I use a strip of tin-foil, or other metallic surface, made smooth, and washed over with varnish of bees-wax, or other non-conducting substances. Upon this prepared tin-foil or smooth metallic surface, washed over with a non-conducting substance, the message is written with a fluid composed of colored caustic soda. After the message is written, a wet sponge easily washes away the varnish from the letters or message, leaving the writing metallic on a non-conducting surface of varnish. The tin-foil or metallic plate is in communication with one pole of the battery or instrument; the opposite pole of the battery passes over the surface of the tin-foil or metallic plate in the shape of a steel point, or a number of points passing over the plate or foil covered or washed with the non-conducting varnish. The electrical current or connection is broken; but in passing over the letters or symbols written on the plate or tin-foil the current is instantly connected. This connection is instantly indicated on the receiving-instrument by blue marks on a prepared paper soaked in prussiate of potassa, transmitting the exact shape or form of the written characters or symbols. Any caustic alkali may be used as the writing fluid.

ELECTRICAL STATIC REPULSION.

FRESH interest is from time to time being awakened in those erratic celestial visitants of our system, about which there is so much that is still enigmatical. The general appearances they present are familiarly known. Their enormous volume is apparent; but not less demonstrable is the extreme tenuity of the vapors or gases composing them; through which, in thick mass, small stars shine with almost undiminished brightness, and traversing rays of light suffer no perceptible refraction. It is further known that the sun has a powerful influence on this cometary matter; for the comets tend to a more condensed and globular form when at a distance from him; but, on coming nearer, the substance increases in lightness and volume, and alters in form, giving the phenomena of the *tail*, which is most extended at the perihelion, and, generally turned away from the sun, appears subject to a repulsive force exerted by him.

The question as to the nature of this force has not yet received a decisive answer from physicists, but there is strong probability that it is of electrical nature. This was the

opinion of Olbers, and M. Faye's observation that the force diminishes with the square of the distance, and that it is proportional to the active surfaces, is in accordance with the hypothesis. M. Zöllner's theory of electric repulsion between the sun and comets is based on the statical repulsion of two electricities of the same name. But there is an evident difficulty here, in the fact of the distance between two celestial bodies, like the sun and a comet, being too great for polar action to be possible; the action of the two electricities should neutralise each other.

The subject appears to have important new light cast upon it from a series of researches by two Austrian observers, MM. Reitlinger and Urbanitzky, described recently to the Vienna Academy. If a finger or any conductor be brought near the luminous column in a Geissler tube, an attraction is observed, which has been explained by the known laws of electrical influence. But these observers, experimenting with a number of tubes, found some which gave a pronounced repulsion instead of an attraction. These exceptional tubes contained, one bromine, the other perchloride of tin. Besides repulsion, the tubes showed a peculiar green light on the side towards which the column was forced; a kind of electric phosphorescence.

Examined spectroscopically, both tubes gave like spectra, and the most visible parts presented the three bands which are generally attributed to the spectrum of carbon, and which are met with in cometary spectra. This identity of spectra is accounted for by supposing that the light was not furnished by the gases that had been introduced, which may have been absorbed by the electrodes, or precipitated on the glass; but by a trace of some rarefied gas of another kind.

The authors then prepared a number of tubes with various gases (air, oxygen, hydrogen, nitrogen, carbonic acid, and coal gas), exhausting to 2 to 8mm.; and in all these cases they found attraction. But, on pursuing the rarefaction further, the effect was reversed; they obtained repulsion. This became more and more pronounced, so long as the nebulous light was not replaced by a singular and stable sort of stratification, which appeared unfavorable to the effect. The light of the negative rheophore shows neither attraction nor repulsion. The rarefaction was continued down to 0·2mm.

When one pole of the induction coil is connected to one of the electrodes of a Geissler tube, and the other pole connected to earth, the interior of the tube may be rendered luminous (a Smee battery of eight elements was used). In this case there is marked attraction in gas having a tension of 6 to 8mm. Continuing the rarefaction, you come to a neutral point; thereafter the same gases give a repulsion quite as pronounced as the previous attraction; and it may even be observed at a distance of three to six centimetres. This repulsion always increased with the rarefaction, and it was the greatest possible with the greatest degree of rarefaction, viz., 0·2mm.

There is another and still more striking form in which the phenomenon can be studied. A wider tube is employed, somewhat like the electric egg. The nebulous light produced has a remarkable resemblance to the tail of a comet. The authors thought they could even distinguish in it the two principal forms which are presented in drawings of comets, according as the pole employed was positive or negative. The repulsion produced by the finger was here very strong, and manifest at a great distance. When an insulating substance (*e. g.*, an ebonite plate) was brought towards the light, instead of a conductor, there was no repulsion; which proves that the phenomena in question were truly electrical.

Whether or not the theory of cometary repulsion thus propounded be the true one, the apparent similarity of conditions and phenomena in the two cases is certainly remarkable, and the discovery of this new form of repulsion is one of considerable interest. We may note, in conclusion, that to account for those celestial repulsions M. Faye has endeavoured to prove experimentally a repulsive force exercised by incandescent surfaces. MM. Reitlinger and Urbanitzky are of opinion (also based on experiment) that the conducting nature of the bodies employed by M. Faye was more important, for the success of his experiments, than the incandescence.—*Telegraphic Journal.*

ELECTRO-MEDICAL GALVANOSCOPE.

J. MORIN.

CONSISTS of an ordinary two branch electro-magnet, placed vertically, the breach being in the air. A magnetic needle is suspended by one of its poles over the breach, through which it penetrates by means of a large hole. The lower free pole of the needle descends as far as the level of the lower part of the electro-magnet's helices, between which it is able to oscillate. The needle is long enough to penetrate the breach to the height of its neutral point, thus nullifying at that spot all reciprocal action. On making a current circulate in the helices the two poles act in the same direction upon the free pole of the magnetic needle, causing it to be displaced towards one of the helices according to the direction of the current. This apparatus is said to answer the purpose for which it has been devised.

THE FIRST IDEA OF THE TELEGRAPHIC DIAL.

IN a work written by Father John Laurechon, a Jesuit, printed in 1624 at Pont-à-Eousson, under the title of "Récréation Mathématique composée de plusieurs problèmes plaisants et facétieux," there is to be found a curious passage, well deserving to be quoted: "It is stated, that by means of a magnet, or any stone of the kind of loadstone, absent persons could communicate with each other; for example, Claudius being in Paris, and John in Rome, if each had a needle rubbed with some stone having the power, as one needle should move in Paris, the other could move correspondingly at Rome; Claudius and John could have similar alphabets, and having arranged to communicate at a fixed time every day, when the needle had run three times and a half round the dial, this would be the signal that Claudius wished to speak to John and to no other. And supposing that Claudius wants to tell John that 'the King is at Paris,' he would move the needle to the letters *t, h, e,* and so on. The needle of John, agreeing with that of Claudius, would, of course, move and stop at the same letters, and by such means they could easily understand and correspond with each other. This is a fine invention, but I do not believe there is in the world a loadstone having such a power, and besides it would not be expedient, as then treason would be too frequent and too secret." Father Laurechon used to write under the assumed name of H. Van Etten. Annexed to the passage quoted, there is a diagram of a dial, with the 24 letters, having the needle fixed at the letter A. A similar allusion is to be found in the Dialogues of Galileo.

PHELPS'S ELECTRO-MOTOR PRINTING TELEGRAPH.*

IN our supplement, No. 53, page 881, we gave illustrations of the construction of this ingenious printing mechanism, and we now conclude the subject, by describing the electromotor by which the instrument is kept in motion.

The electro-motor and its governor are mounted upon the base of the instrument at the left and to the rear of the hollow column A, which contains the transmitting mechanism. The motor consists of eight electro-magnets arranged in a circle, within which a revolving shaft carries a circular row of soft iron armatures, five in number. The commutator is so connected that the electro-magnets act successively as the armatures come within their influence, and cease to act just as the latter arrive at a point opposite to the poles of the magnets. By this means a constant attraction is exerted upon the armature, which causes the shaft to revolve with great rapidity. The motor is provided with a centrifugal governor, which acts to reduce the quantity of electricity flowing through the actuating magnets whenever the speed becomes too great, by which means its motion is rendered perfectly uniform.

Fig. 10 is a horizontal transverse section of the motor, showing the arrangement of the electro-magnets and armatures, and construction of the commutator, and fig. 11 is a vertical transverse section of the same. The figures are half the size of the actual parts.

The elector-magnets R R, etc., eight in number, are arranged in a circle within a cylindrical case R_1. The magnets

FIG. 10.

are insulated from each other, and placed close together within the frame of the machine, by means of insulated rods s_2, to which the magnet wires are fastened. Five of the forty commutator springs $z z z$, etc., are connected to each of the conducting segments X X, by means of studs z_1, passing through the frame and insulated therefrom, each fifth spring being connected by means of its corresponding stud to the same conducting segment. The frame or case R, of the motor has a circular opening in its top plate, within which opening the contact wheel Y runs. This wheel Y is mounted at the end of a link Y_1, which is hinged to a projection from the main shaft Q, and is constantly pressed against the inner edge of the opening in the frame by a spring y_1, so that the frictional contact is always sufficient to turn the contact wheel. The periphery of the latter is grooved as shown at y, and runs upon the edge of the open-

and the platinum faced contact wheel V, a permanent connection is made between the screw s, and the frame of the machine by means of a resistance coil Z, which, when the contact between s, and V is interrupted, conveys a sufficient quantity of current from the battery to the motor to cause the latter to revolve, but at a rate of speed considerably less than the normal rate to which the machine is adjusted. The effect of breaking and closing the contact between s_2 and V is therefore merely to increase and diminish the total resistance of the circuit by an amount equal to the value of the resistance Z, and the extra or induced current, having a path through the coil Z, occasion but an inappreciable spark upon the contact wheel V.

The revolution of the motor is communicated to the instrument by means of a pinion Q_4, which gears into a wheel Q_5, of about four times the number of teeth, and this in turn is

FIG. 11.

PHELPS'S ELECTRO-MOTOR PRINTING TELEGRAPH.
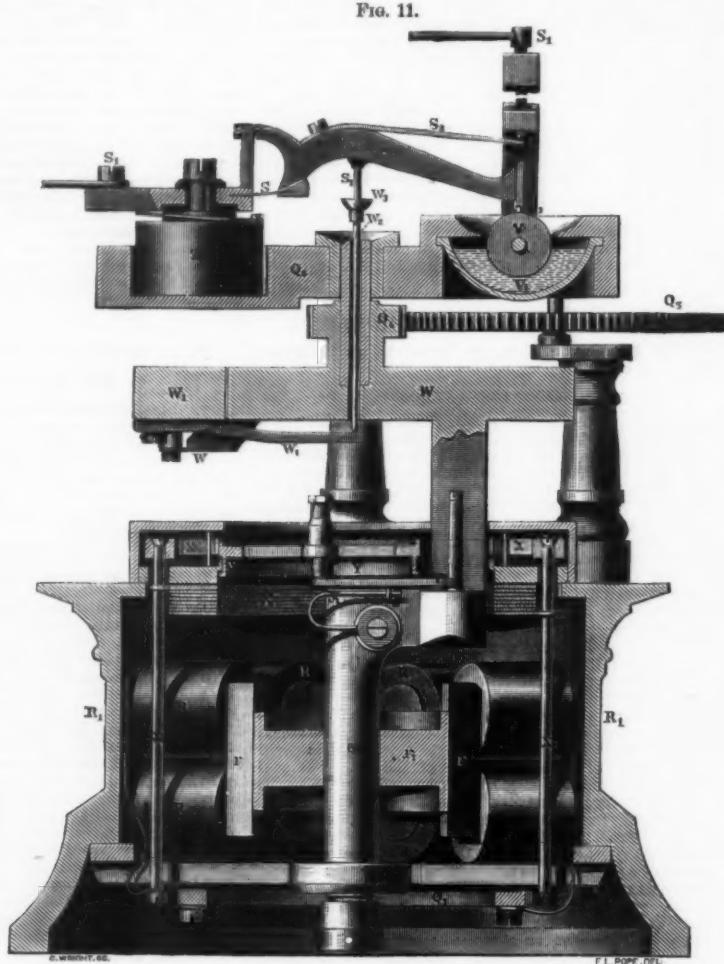
are of the ordinary form, having cores 0.5 inches diameter, and 1.35 inches in length, wound with insulated copper wire 0.042 inches diameter. Five soft iron armatures, r r, etc., are arranged at equal distances around the periphery of a hub r_1 of brass, upon a vertical shaft Q supported at its lower end in an adjustable step or bearing Q_1 and at its upper end in a top plate Q_2. The motor battery is connected by the screw s, to the insulated lever S, which is mounted upon a spring s, and pressed downward by the action of the screw S_1, acting upon a flat spring S_2. The screw S_1 serves to regulate the speed of the machine in the manner about to be explained. W is a thick piece of metal mounted upon the main shaft Q of the motor, and serves as a counterbalance or fly-wheel. A section of this W_1, is mounted upon a spring w, and has an arm w_1, attached to it. The rapid revolution of the shaft Q when the motor is in motion, tends to throw the section W_1 (which acts as a weight) outwards by centrifugal force. When this takes place the arm w_1 is raised, then pin w_2 (which passes through the upper part of the shaft Q, the latter being hollow), is forced upwards and by means of the cup w_3 and insulated pin s_4 raises the lever S by bending the spring S_2. V is a platinum faced wheel or disc, which revolves slowly by means of a worm acting upon a toothed wheel fixed upon its axis, not shown in the figure. The wheel V revolves in a cup V_1, partially filled with oil. The platinum edge of the wheel V and the platinum stud s_2, on the lever S are in contact at all times, except when the speed of revolution exceeds the rate to which the machine is adjusted by the screw S_1. The constant motion of the wheel V keeps the contact surfaces clean, and there is but little friction on account of the oil. When the speed of the machine becomes too great, the weight W_1, being thrown out by the centrifugal force as its supporting spring w bends, raises the inner end of the arm w_1, which lifts the lever S by means of the rod w_2, breaking the contact between s_2 and V, and by thus diminishing the battery force, at once lessens the speed of the motor. The current from the motor battery, passing through the lever S, wheel V, and frame of the machine to the commutator next described, is directed through the several electro-magnets in succession, and finally finds its way back to the battery by a common battery wire connected to the insulated metallic ring Q_3. The number of contact springs in the commutator, is equal to the number of electro-magnets multiplied by the number of armatures, viz., forty. Each separate electro-magnet is charged each time it is approached by either of the five armatures during their revolution. This is effected by connecting each of the magnets R R, etc., with one of eight flat metallic segments X (which

ing, as upon a railway track. The contact wheel Y also runs in contact with the ends of the commutator springs $z z$, which yield sufficiently to bring each successive one into contact with the wheel before the preceding one is out of contact. The portion of the periphery of the wheel Y, which runs in contact with the springs, is of larger diameter than that which runs upon the frame, as will be seen by referring to the figure. The object of this arrangement is to cause the surface of the wheel Y to slide or rub upon the springs $z z$,

geared directly to the hollow wheel E upon the shaft C of the transmitting machinery (Figs. 2 and 3).

The arrangement of the main and local circuits of the Phelps instrument is shown in the diagram, Fig. 12. The switch is placed at the right of the keyboard, and is represented in position for receiving. The current enters at 1 and passes through the relays 2 and 3, thence by wires 4, 5, and 6, through the switch, and thence by wires 7, 8, 9 and to the earth. The relay 3 is a polarized relay of Siemens'

FIG. 12.
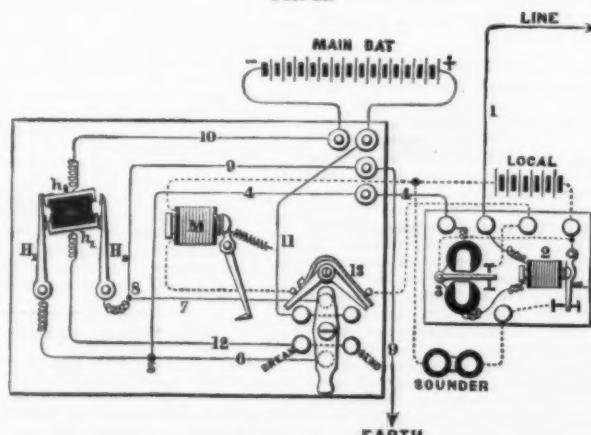
PHELPS'S ELECTRO-MOTOR PRINTING TELEGRAPH.

as it revolves, and thus keep the surfaces clean without unnecessary wear.

It will of course be understood that the wheel Y forms an electrical connection between the frame and the successive commutator springs as it revolves, and thus charges the electro-magnets in rotation, each magnet being charged five times during one revolution of the main shaft Q, by which means each armature is attracted and released at the proper moment.

In order to avoid the spark which would otherwise be produced at each breaking of the contact between the stud s_2

or other suitable construction, and closes its local circuit under the influence of the positive pulsations sent to line by the transmitting instrument. The auxiliary relay, 2, has a non-polarized or neutral armature, and is very much less sensitive than the relay 3, so that it is not affected by the ordinary pulsations passing over the line. The object of this relay is to enable the receiver to break or stop the sender during the transmission of a dispatch, or to answer a call signal, as will be hereafter explained. The relay 3 operates the printing magnet M by means of a local battery of six small cells. If the receiver wishes to stop the sender, he

turns his switch to the position marked "break," which throws his own main battery into the line circuit, by way of 5, H, A, 10, 11, switch lever 15, A, H, and 8. The effect of this is to double the strength of the pulsations passing through the relay 2, and cause it to actuate a small sounder placed in a branch circuit from the common local battery. This effect takes place upon both the sending and receiving instruments, and the sending operator is thus notified of the interruption by the working of the sounder. The break 13 opens the local circuit of the printing magnet M, whenever the switch is turned to "break," and thus prevents the printing mechanism from operating, and introducing superfluous characters into the printed record. When sending, the switch is turned to the point marked "send," the connections being precisely the same as when turned to "break," except that the local circuit of the printing magnet now remains intact, and the printing mechanism may be stopped, if desired, by pushing in the stop O,, in Fig. 7.

The manipulation of this instrument is theoretically very simple, although it will be obvious that a vast amount of practice is required on the part of an operator before he can expect to be able to finger the keyboard with the skill and rapidity which is necessary in order to develop the full capacity of the instrument, which exceeds even that of the combination. For example, an actual trial was made, an operator sending continuously for five consecutive minutes, the matter being an ordinary newspaper despatch from Washington, selected at random. The number of words transmitted during this length of time was 290, containing 1,634 characters, inclusive of letters, points, and spaces, or 58 words per minute—a rate of speed which some of the more skillful operators can maintain for a long time. By a careful analysis of the above despatch it was found that the alphabetical sequence of the letters was such that an average of two characters could be printed from during each revolution. Therefore, by depressing two keys and permitting the instrument to revolve at the normal rate, its actual capacity was easily ascertained by counting the number of revolutions per minute. This was found to be 166—332 letters, or 59.3 words per minute.

The operator, before commencing to transmit a despatch sets his motor in motion by closing the circuit of the motor battery by means of a button switch at the left of the keyboard. He then turns his switch to "send," and depresses a certain predetermined series of keys, the pulsations from which operate the relay and printing magnets of each instrument with a distinctly audible sound, serving as an alarm. The receiving operator signifies his readiness to proceed by changing the position of his switch from "send" to "break" for a moment, which causes the sending operator's pulsations to manifest themselves upon his own sounder. The sender then depresses his blank or dash key, transmitting the pulsations in groups of three, with an interval between each group, so that the receiver may adjust the speed of his motor. When the latter has accomplished this, he signals the sender by turning the switch to "break" for a moment. The sender then allows the instrument to make a few revolutions, so as to bring the automatic unison of the receiving instrument into action, and then proceeds to transmit his communication, letter by letter, being careful to commence with the dash or blank key. In case the two instruments get out of correspondence, which seldom happens unless the line is in bad order, the receiver can stop the sender at any time by turning the switch to "break."

The local battery which drives the motor consists of two large Bunsen cells, charged with Poggendorff's bichromate solution in contact with the carbons in the porous cell, and diluted sulphuric acid in the outer or zinc cell. The containing jars are of glass, 9 inches in diameter and 6 inches high. The zinc cylinders are 8 inches outside diameter and 0.5 inches thick, within which is placed a porous cell 7.5 inches diameter. The carbon element consists of two rectangular plates, placed parallel and about two inches apart, each plate being 5 by 6.5 inches. This battery will run the motor continuously for fifteen hours without requiring a renewal of the bichromate solution.

It has not been found necessary to adapt any repeater to this system, as it has proved itself capable of working direct at full speed between New York and Chicago, a distance of 1,000 miles by the route of the line.

This instrument has been for some time in successful operation between New York and Washington, in connection with Mr. Gerritt Smith's improved Quadruplex. Only two instruments at each end, however, being worked at present, for the transmission and reception of messages; the other two sides of the Quadruplex being simply used for breaking or signalling. With two instruments at New York, and two at Washington, connected by a single wire, 110 words per minute are regularly transmitted in the ordinary course of business, If the instruments should require it, two more instruments at each end can be connected on the same wire, thus enabling the operators to transmit 220 words per minute upon a single wire, each operator sending at the ordinary rate of 55 words per minute.—*Journal of the Telegraph.*

HEAT FROM ELECTRICITY.

THE results of a series of experiments by M. Cazin and the heat measurements gave the following law: "When straight iron core is surrounded by a series of similar coils, when the current flows in alternately opposite directions, and when these coils produce poles at equal distances from each other, the quantities of heat which are produced in the core by the same interrupted current are inversely proportional to the squares of the number of intervals."

In the foregoing experiments heat was developed in the core, while a regularly interrupted current produced in this core a series of magnetizations and demagnetizations. M. Cazin now sought to determine the cause of the development of heat, and proceeded as follows: Round the iron core in the petroleum thermometer two coils of 480 turns were passed, one of them being in the interrupted magnetizing circuit, while the other formed a special circuit, while at each turn of the interrupting apparatus was closed. The first coil could now induce a current in the second, if the closures of the two circuits took place at the proper times, as might be arranged at will. These experiments gave the greatest development of heat when the circuit of the second spiral remained continually open. The heat was not altered when the circuit was closed at closing of the magnetizing current. There is thus no thermal action during the variable period of closure. Lastly, the heat was smaller when the circuit of the second spiral, during the opening of the inducing circuit, was closed; it went down as much as the half. "It thus proved that the production of the magnetic heat takes place during the opening of the voltaic circuit, consequently, that it accompanies the disappearance of magnetism in the core."

NEW INTERMITTENT FILTER.

THE principal feature of novelty in this filter by Mr. Denton, is that it intermittently runs dry, so that the filtering material becomes aërated, and the impurities detached by it from the water are to a certain extent oxidised. During the day, when the water is being drawn off for use, the extent to which aëration and oxidation will take place will, of course, depend upon the rate at which the water is used, but at night several hours may generally be counted upon during which aëration and preparation for further effective
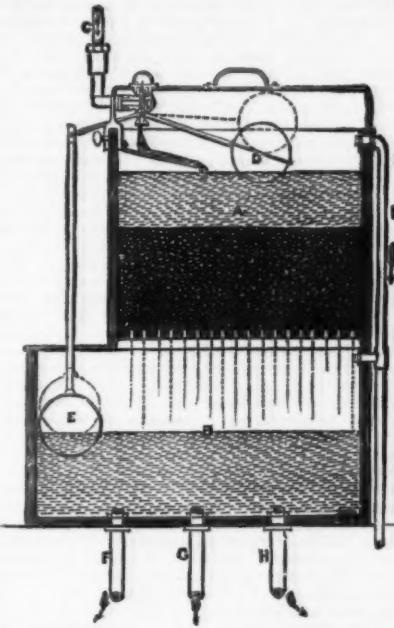
filtration may take place. Referring to the section, A, is the cistern containing the filtering material. The bottom of this is perforated and is placed over a second cistern, B, which contains the filtered supply. C is the supply pipe from the main or from a service cistern, and D is a ball-cock which regulates the admission of water to the filter as the filtered water is drawn from cistern B. The ball, D, however, cannot fall to admit fresh water, except in unison with the ball, E, which acts by a lever upon the same valve. An interval is thus gained between the admission of water to the filter A, and the partial emptying of the cistern B, and during this interval aëration of the filtering material may take place. I is an overflow pipe connected with both cisterns. With reference to this it may be remarked that, although the current induced by the water falling from the cistern A, will most probably tend to draw air with it as it passes the connection with the cistern B, still it is possible, as the short piece of pipe is now placed, for some water from A to run unfiltered into B. If this piece of pipe were placed at an angle, so as to dip from the cistern, or if the connection were made by a double angle piece, this risk would be avoided.

The pipes F G H for supply to different parts of a building may, of course, be placed either at the side or at the bottom of the cistern, and may be more or less in number.

The cisterns are made of stoneware, and the ball-cock will withstand very high pressures.—*The Engineer.*

ARCHITECTURAL SCIENCE.—CARPENTRY.

ELEMENTARY REPLIES.

QUESTION.—*State in a few words the relative effect of position in the pieces of a frame or truss.*—The strains in a framed structure are regulated by the position of the various timbers composing it, and their relative position, or the angles which one piece makes with another, determines the proportion and magnitude of the strains, and the consequent strength of the framing. To take, as an example, a triangular frame loaded at the apex—the greater the pitch of the two rafters the less the tensile strain on the tie and the cross strain on the rafters themselves; the nearer the rafters assume the vertical, the greater the load they can bear. In rafters of low pitch a great cross strain is exerted; and this strain, in all good constructions, should be reduced to a minimum. An application of the parallelogram of forces will determine the best position of the timbers, and their correct sectional area to best resist the strains; or the same result can be obtained more accurately by trigonometrical calculation.—T. N.

QUESTION.—*Which is the most economical mode of cutting a beam from a log?*—The largest beam that can be cut out of a log of ordinary form (*i. e.*, nearly circular in section), and fairly straight, is a square one, the diagonal of which will be the full diameter of the heart-wood of the log at the smaller end. By this plan the beam will consist wholly of perfect wood, and the slabs taken off will contain all the sap wood, and but a small portion of sound wood. But an oblong section is best adapted to the beam, and, should this be the form required, it is better to set up the log, so that a slab may be taken off the side most nearly straight, of depth sufficient to give one side of the beam; the requisite breadth of beam is then gauged on at the ends, and lined through, and these two deep cuts sawn. The piece is then laid flat, and a chalk line plied on the outer side as near as possible to the margin of the heart wood. The depth is set off parallel to this, and two flat ends made, completing the beam. The thicker offcut taken from the side of the beam contains a considerable portion of heart wood, which may be cut into planks the deepest way, or into timbers of smaller scantling, as plates, rafters, or quarterings.—AUBERY.

QUESTION.—*Give proportions of the strongest beam that can be cut from a log.*—The strongest beam that can be cut out of a log has its depth to its breadth in the ratio of √8 to 1. The method of describing the beam geometrically is to trisect the diameter of the circle, and from these two points erect perpendiculars cutting the circumference of the circle. Connect these circumference points with the ends of the diameter by straight lines, and this will give the rectangle required. In ordinary construction the sap wood is left on; but in a beam of special strength the sap wood is cut off, and the rectangular beam cut entirely out of the heart wood. In

positions where the beam is chamfered a portion of the sap wood is taken off, without in the least weakening the beam The stiffest beam capable of being cut out of a log has the depth to the breadth in the proportion of √8 to 1.—T. N.

ADVANCED REPLIES.

QUESTION.—*Give a sketch of roof for a span of 30ft. without a direct tie.*—The accompanying sketch shows a light and economical means of framing principals without a direct tie. The ends of each cross brace resting on wall plates receives the tenon at feet of principal rafters; the braces are halved and shouldered where they cross, and tenoned to under side of rafters at a point one third of their length from apex of roof. The heads of principal rafters abut
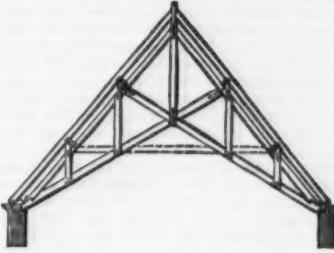
against each other, and are kept in position by a pair of suspending pieces, which also clip the crossing of braces to prevent their sagging. Intermediate pieces are notched and halved on to principal rafters and braces, immediately under the purlins—the purlins are cogged on to principals, and further supported by brackets—the common rafters are notched on to purlins, their feet being bird's-mouthed on to pole plates; a cross stay-piece is notched down on both plates, and fixed to feet of common and principal rafters. The whole of the joints are strengthened by straps and bolts to prevent any sinking of truss, and consequent outward thrust on walls—the whole of the different parts being framed on the principle of triangles if the joints are properly secured. Collar pieces could be introduced, as shown by dotted lines, according to the nature of ceiling (if any) required.—S. M. E.

QUESTION.—*Describe the best means of framing principals without ties.*—Such principals may be framed with a collar-beam, king-post, and braces, like an ordinary king-post truss, with the addition of braces between feet of principal rafters and collar. Cross-bracing, from feet of one rafter to opposite rafter, with clips, straps, and suspending pieces, or rods, forms a good means of framing such principals. This framing may also be strengthened so as to prevent outward thrust on walls, by having additional braces from principals carried to a point below base of roof, either framed into vertical wall posts or resting on corbels. This method should only be adopted for roofs with a steep pitch, as any shrinkage causing a settlement of roof would exert a considerable outward thrust on walls, increasing with the flatness of pitch. Where the walls are sufficiently thick, the danger of outward thrust may be avoided by using two wall-plates, bedded on outer and inner edge of each side wall, with a cross sill or shoe notched on to both, into which the feet of principal rafters and vertical struts are framed—the steeper the pitch the higher the point of connection between strut and rafter. By this means the pressure is transmitted more vertically and more evenly on to walls. Mansard roofs can also be framed so as to omit the lower tie, giving all the advantages of additional headroom, suitability for vaulting, etc. Another means frequently adopted for framing principals in open roofs, with a steep pitch, is by means of hammer beams instead of direct ties. The hammer beams project from springing—the ends projecting from walls are supported by brackets or braces, usually of a curved form, having their lower ends resting on posts or corbels below springing line of roof. The feet of principal rafters are framed into ends of beams resting on walls, while from opposite ends other posts and braces support another series of hammer beams, or a collar, with posts and raking braces under principals, according to pitch and space. The pressure on such roofs is transmitted through the arched braces to a point some distance down the walls, where it is less likely to affect their stability. In old Gothic buildings the walls at such points were usually strengthened by buttresses, the framing being of oak highly ornamented. In some instances the arched braces or ribs are carried from ends of hammer beams direct to ridge, or the hammer beams are omitted and the ribs carried from corbels and springing to apex, or to a collar framed between principals. All such roofs are constructed on the principle of the arch, and the higher the rise the less the horizontal thrust on walls. Perhaps the best means of framing principals without ties, so as to overcome the danger of shrinkage in the timbers, is by forming curved laminated ribs with thin planks in long lengths, bent on the flat to a template, one over the other, breaking joint. The ribs being strapped and bolted together are secured to wall plates, and vertical wall posts. The principal rafters are fixed to ribs by means of bolts and radial pieces in pairs, tangent pieces being used at haunches between rafters and vertical posts, and at crown between rafters, tightly bracing these parts into triangles and preventing thrust on walls, the whole thrust being transmitted vertically through ribs on to the corbels or offsets in walls, below springing of roof. The number of layers should be increased at haunches to resist the pressure and prevent change of form, where segmental or semicircular ribs are used. Such ribs are also well adapted for open roofs of the Gothic form, already described, and may be made an ornamental feature in the building. Their strength, compared to that of a solid rib, is as one to the number of layers used in their construction. Another method of forming curved ribs with short planks placed on edge in two or more thicknesses, with ends abutting and breaking joint, is a good means of supporting principals for large spans. The thicknesses are either bolted together or secured by horizontal ties passing through mortise holes cut in ribs, with pins on either side to keep them in position; or the ties may be notched to edges of ribs and keyed together. The feet of such ribs are secured to wall plates on offsets at a considerable distance below junction of roof and walls; the principal rafters are fixed to ribs by means of posts, suspending pieces, straps, etc., with a collar at ridge and braces at haunches. The lower edge of ribs may be worked to the curve. Such ribs are considered as strong as a solid one of the same depth, and of a breadth less by one thickness.—S. M. E.

QUESTION.—*Describe a few old examples of timber-framing.*—Few old examples of roof-trussing show perfect mechanical principle, except those of the hammer-beam system, which

are the most beautiful and the most ingenious. The best and finest example is the roof of Westminster Hall, though here the hammer beam performs a secondary part, conducting the weight from the principal rafter to the curved brace, which continues the thrust a considerable distance down the wall. Hampton Court and Eltham Palace are very noted roofs of this kind. Sometimes two, or even three, hammer beams are used, framed together, with uprights and curved braces.—DRYB.—*The Building News.*

THE GRINDSTONE.

From J. E. MITCHELL's Pamphlet on Grindstones, Phila.

IN the whole range of mechanics, with all modern developments and enlarged capabilities, there has been applied no mechanism nor process yet able to supersede the grindstone in its peculiar office. It is the one thing in mechanic arts that improvement has not added to, or invention displaced; while the pruning hook and plough are of equal antiquity, the spirit of improvement has touched both but left the grindstone unchanged. Its utility in the early ages was great, and science has not lessened its value any by its perfection of other means for like results. It has been found in use among uncivilized people, and yet has its place with nations most advanced. Writers of fiction knew it would not conflict with the appearance of truth to ascribe it a place among barbarians. It is among the few implements of handicraft mentioned in Scripture, though there only named for milling purposes; it is the same in form and in universal use—a round revolving stone. In a scriptural research for the articles of handicraft mentioned then, we can look through the "eye of a needle" and find the grindstone beyond, its origin lost in the darkness of antiquity. It is not meant to confound with the mill stone of antiquity the grindstone of to-day, which the Encyclopedia mentions as "a flattish circular stone of various diameters, employed in the cutting and sharpening of edged tools, precious stones, etc., and the grinding of steel, glass, pottery, and the like. They are made of sandstone, or sandstone grit." The grindstone now has scarcely a wider capability or greater usefulness than when we first hear of it. Although limited as its qualifications may be, it serves its purpose as nothing else can. Improvement has furnished us wheels of composition which only to some extent serve some of its purposes, but the grindstone still remains unsupplanted. It is a tool of the utmost nicety in proper hands and properly understood, and is capable of performing with speed and precision its limited agency, beyond the powers of any modern tool. It is perhaps found best handled in its purpose of grinding dies for cut nails, where its proper use constitutes an occupation not to be attained very perfectly by a short apprenticeship with it. That known as the "bead stone," used by makers of cut nails, is a tool of the utmost perfection of workmanship, not to be meddled with by the inexperienced, however lightly, without the result being noticed by the eye of the experienced nailer. The milling machine, the planer, the
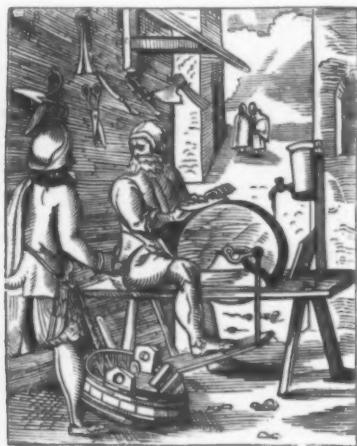
A GRINDSTONE OF THE SIXTEENTH CENTURY.

FAC-SIMILE OF AN ENGRAVING PRINTED BY H. SCHOPPERUM, FRANKPORT-ON-MAIN, IN 1548.

file, the lathe and emery wheel, do much of the work of the grindstone, but it still performs to perfection its needful though limited purposes. The importance and nicety of it, as a means to a purpose, is only known by those who know how to prepare and keep it in order.

Its utility or importance could not be guessed at, were one to look at a crooked and badly kept grindstone; but in the hands of those who know its merit, with its even surface running as true as any turned wheel, it will perform work with a rapidity and precision attainable by no other means. In the hands of those who are learned in its use and keeping it is capable of adaptation to intricate and fine work, but with those who do not understand it, it is rude, and the very opposite of what the educated craftsman would select for any purpose of fine employment.

An heirloom of antiquity, but used among us as we received it, and without any attachment or improvement; capable of its complete functions only when well kept and well applied, and this is only found with those whose craft education is solely to handle it. It alone can cut and shape expeditiously that which is prepared to cut and shape all other hard materials—cast steel hardened. It is still employed to give the finest edge, the most even surface, the brightest polish, and is the quickest to accomplish it. The emery wheel does but a few of its purposes, and nothing that we have could supply its place. The file has its own peculiar uses, but in contact with the grindstone, its thousand small cutting edges would be reduced to polish plainness. It is found a necessary implement on the farm, and is still required where the finest of instruments are made, or the hardest of metals are worked. It has come to us as we have it, and in all likelihood will pass on down to other ages the same—a simple circular stone, swiftly revolving on an axie.

It accompanies those who "go down to the sea in great ships," and moves along the frontier with the advance of civilization. All nations use it, and it is perhaps, with all, the one piece of mechanism that bears the same form, and is the same in principle. More or less directly it takes part in the greatest modern material enterprises; it has, no doubt,

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assisted to fashion the implements of many of the lost arts, and is still needed in many of the requirements of arts of the present day.

As ages revolve and invention gives to the world new devices, may it be found more the agent in forming the ploughshare and pruning hook, than in sharpening the sword.

SANITARY HOSPITAL APPLIANCES.

THE system Mr. Banner has perfected is exceedingly simple, and is, in fact, an elementary natural law, by virtue of which a column of air can be set in motion by the difference of pressure of the atmosphere in a pipe or siphon. Mr. Banner simply admits air at the bottom of his soil-pipe, and allows it to escape through an upper outlet, the current of air being facilitated by a cowl which operates in giving a free vent to the sewer gas, and also, by producing a vacuum acts as a suction pipe. All that is needed by Mr. Banner's system is plenty of water to cleanse the pipes and plenty of air to prevent stagnation. A single siphon-trap answers the purpose for a large house, and this is always accessible and can be readily cleansed if necessary. A through current of air is constantly maintained by an inlet placed just above the trap and an outlet above roof, to which is affixed the cowl, preventing any down draught. But let us describe the principle as applied to the old part of Guy's Hospital, where, from time immemorial, the old leaden-trapped soil pipes have been in use. Mr. Banner has here connected the soil pipes to a 12 in. glazed stoneware socketed drain pipe, into which they discharge, and at the extremities of it has erected two cast iron pipes of about 9 in. diameter, one acting as an inlet and having an ingress cowl-head admitting air from above the roof of the building, and another similar one acting as an outlet-shaft fitted with a ventilating cowl. A considerable section of the soil and waste pipes of the old building is thus completely ventilated by a constant current of air passing through them. The old drains are similarly ventilated. Between the new wing and the hospital, we see an ordinary grating in the road. This has been converted into an inlet for the drains passing through the old building; an air shaft in connection with this drain (which is 15in. at the lower end, and 12in. at the higher), being carried up the side of the building, and presents the appearance of a large stack-pipe with an outlet cowl. To show the rapid draught through this pipe, Mr. Austin placed an anemometer at the surface of the grated opening, when a velocity of 510ft. per minute was registered under very ordinary circumstances. We also proved the draught by the ignition of some hempen material and placing it at this inlet. In a few minutes we saw the smoke rapidly escaping from the ventilating cowl, showing practically the efficient operation of the system. We understand the entire length of the pipes the current has to traverse is upwards of 360ft. In connection with the system we may mention that every soil-pipe has a patent drain-trap fixed at the lower end of each soil-pipe. We observed the action of one of these simple self-acting contrivances in which the pan is balanced on the steel-yard principle, so that at every flush the pan releases its contents and rises, sealing effectually the outlet of soil-pipe. We observed various inlets, one to each pipe, just above this trap, and, by personal observation, we ascertained in every case a strong inward suction. We may also mention the use of Dean's outside traps, a capital and simple means of taking lavatory or other wastes, and also Pearson's "trapless closet pan." Our examination has convinced us that the simple principle Mr. Banner has applied is the only one appliable to the ventilation of public buildings.—*Building News.*

ANCIENT ROMAN AQUEDUCTS.

FATHER SECCHI has written a letter to the French Academy of Sciences on the "Hydraulics of the Ancients." The monuments he mentions have been mostly discovered by him in the environs of Rome. The first mentioned by him is an aqueduct built at Alatri, 200 years before the Christian era. It is an inverted syphon, its lowest point being 101 metres below the orifice from which the water flowed into the town; so that it sustains at its bottom a weight of at least eleven atmospheres. The pipes of this aqueduct are of earthenware, buried in a thick bed of concrete; they were very firmly joined together along a length of 7½ miles. This work seems to have been the model on which Vitruvius founded his description of syphon aqueducts. The second remarkable relic of antiquity found at the same place is a complete system of drainage composed of enormous porous stoneware pipes, a metre in length, fourteen centimetres in diameter, and only two in thickness. This was done to dry up a plain intended for military manœvres. Next come inclined planes expressly laid down on substantial foundations and near the top of a mountain, in order to collect rain water on a large surface, with a large basin to purify it, and cisterns to preserve it. This was done to provide the town of Segni with potable water. Then follow contrivances of the ancients for turning the water filtering through porous grounds into the aqueducts by turning the clayey strata to account. They used also to rid water of its carbonates of lime by boiling, then cooling it again by applying snow to the outside. They likewise had an ingenious way of cooling their "aqua tepula," which was too warm for drinking after it had been brought over to the Capitol. Father Secchi has discovered the spring whence it came, and found that it marks 18 deg. Cent.—64 Fah.—in winter. The Romans used to mix it with water from the Julia, which only marked 11 deg. The other spring, now called "Preziosa," issues from an old volcanic crater.

INCREASE OF THE STRENGTH OF IRON BY REST.

It has long been known that if a bar of iron is subjected to a strain beyond its elastic limit, and then allowed to rest, it will require a greater strain to break it than would have been needed in the first place. An experiment of this kind was, says the *Railroad Gazette*, made by Messrs. Hoopes & Townsend during the Exhibition. Two pieces of round iron ⅝ in. in diameter were cut from the same bar, and one of them broken in a testing machine at a strain of 30,010 lbs. The other piece was subjected to a strain of 29,000 lbs., when it began to stretch so as to contract in diameter at one place. The strain was then released and the bar laid away for a week to rest, and it then required a strain of 32,000 lbs. to break it. In other words, its ultimate strength was increased 2,000 lbs. by being stretched and allowed to rest. The exact reason for this is not known. The same effect results from drawing wire. Messrs. John A. Roebling's Sons exhibited steel wire which had the extraordinary strength of 308,500 lbs per square inch, although the exact reason of this effect is probably not known, yet doubtless the same cause which increases the strength of the material in the strained bar and in the wire is operative in the process of cold rolling.

DETECTION OF MAGENTA IN WINE.

M. E. BOUILHON.

FIVE hundred c.c. of wine are placed in a capsule, raised to a boil, and evaporated down to 125 c.c.; the capsule is then withdrawn from the fire, and 20 grms. crystalline hydrate of baryta are added. It is agitated to facilitate the reaction, allowed to cool, poured upon a filter, and the precipitate washed with distilled water, so as to obtain in all 125 c.c. of filtrate. It is then necessary to ascertain, by the addition of a few crystals of hydrate of baryta to the filtered liquid, that the precipitation of the coloring matter of the wine is complete; if not, more hydrate of baryta must be added, and the liquid re-filtered. It is then introduced into a flask containing about 250 c.c., with 50 to 60 c. c. of pure ether, strongly shaken, and allowed to settle. When the ether is completely separated from the aqueous liquids it is drawn off by means of a pipette, and poured into a porcelain capsule. A drop of acetic acid at 8° is added, 3 or 4 drops of distilled water, and a little white unwoven silk, consisting of ten threads a centimetre in length. If the quantity of magenta contained in the wine is at all notable, acetic acid produces at once a rose coloration, but when only minute traces are present the ether is allowed entirely to evaporate. The residue consists of a small quantity of aqueous liquid, in which the silk soaks. The capsule is then very gently heated, so as to evaporate the bulk of this liquid, and concentrate the traces of coloring matter in a few drops, thus favoring its fixation upon the silk. This process, if carefully executed, reveals one hundredth-millioneth part of magenta in wine.

ELECTRIC RANGE FINDER.

AFTER the first round has been fired from one of our heavy guns the immense volume of smoke would probably hang about and obscure the object from sight in the battery. Hence the necessity for outside and independent observations, and for the instantaneous communication of the results of these observations to the battery. Here Captain Watkin's electric position-finder comes into operation, and by its aid the course of a vessel can be followed and its precise position continuously indicated. By this means a fire can be maintained from any number of guns in a fort against a ship without the gunners once sighting her, but with the moral certainty of the vessels being hit. The basis of operations is the well-known plan of dividing up a chart of a harbor or of a given area of the sea within range of the guns into squares, each side of which is 200 yards long. Each square is distinguished by a number, and is subdivided into a series of smaller squares, each of which is marked with a letter. In connection with this is an electrical arrangement for indicating automatically and continuously in the fort or at head-quarters the position of the vessel in any one of those squares. Taking the extreme ends of a fort as a base line, the problem given is to construct thereon a triangle, at whose constantly changing apex is the object to be hit, the intervening space being the range. It is solved in the following manner by Capt. Watkin:

At each end of the imaginary base line is an observing station, in each of which an observer can follow the course of a ship through a sight-bar, which is pivotted and free to move in a circle horizontally. The two lines of sight intersect each other at the object, and form the two sides of the triangle erected on the base. As the sight-bars are moved to follow the course of the vessel, they cause a couple of pointers, with which they are electrically connected, to indicate their movements. These pointers are sufficiently long to cover the chart—which is placed in a station or directing center of the battery—and to intersect each other over any one of the squares. The officer in command is thus made continuously aware of the position of the vessel. At the desired moment he telegraphs to each gun the number of the large square and the letter of the subdivision. Referring to his tables, the officer in charge of the gun sees at a glance the elevation necessary for that square, which he gives to the gun and fires. This information can, of course, be conveyed to one gun alone or to the whole number in the fort at the same time. It will thus be seen that, in spite of the smoke, a continuous fire can easily be maintained from the guns so long as the observatories stand.

THE FIELD RANGE FINDER.

The instrument most recently perfected by Captain Watkin is his range-finder for field purposes. Externally this is as innocent looking an apparatus as can well be conceived. It is nothing more than a japanned-metal box 10 in. long by 4 in. broad and 2 in. thick, and having a few holes cut in two of its sides. This instrument packs into a leather case and is slung across the shoulder by a strap. The only accessories required are an 18 ft. measuring tape and three long metal skewers or pickets, with a white semaphore or flag attached to each at the top.

The metal box has its top hinged half way of its length, and the right half is opened and thrown back in use. This displays a small boxwood cylinder about the size of a reel of cotton, and on which is engraved a scale of yards from 600 to 4,000. There is also in view a brass bar having a sliding index, the bar being graduated from 60 to 120 yards, representing the different lengths of base with which the instrument may be worked. The covered half of the case contains two mirrors, somewhat similar to those of a sextant, having a peculiar arrangement of the horizon glass, which allows of a true right angle being at any time obtained, and any index error at once seen and corrected.

In using this range-finder the observer rides out in advance of the battery and plants two of the pickets at points—say A and B—in the direction of the object, one of them, B, at a distance of 18 ft. in advance of the other. And this is the purpose for which the short measuring tape is required. He then runs about 100 yards to his left and plants a third picket, C, with the aid of the instrument at the right angle between the picket, A, and the object the distance of which from his base line he desires to ascertain. By turning the cylinder and reflecting the picket A on to B, he obtains the length of the base A C, and slides the index on the brass bar to the figures representing that length. The observer then returns to his first position, and by again turning the cylinder reflects the picket C on to the object. The figures read on the cylinder will now be the true range, which is thus ascertained without any calculation.

The time occupied in taking a range is remarkably short, being only from about one to two minutes at the outside, including the unpacking of the instrument, but with the assistance of an orderly to plant the pickets. When working entirely alone the operation occupies three minutes, which includes dismounting, hobbling the horse, unpacking the instrument. In the course of some official trials, Captain Watkin satisfactorily demonstrated the rapidity and accuracy with which ranges could be taken.—*Engineering Times.*

OSTRICHES AND OSTRICH FARMING.

ALTHOUGH the name of M. de Mosenthal stands first as joint-author with Mr. Harting of this book on ostriches, we find only some fifty pages at the end of it, and these descriptive of the growth and present condition of ostrich farming, as coming from his pen; the first and larger portion of it, consisting of a monograph of the existing Struthious birds, has been industriously prepared from a great number of sources by Mr. Harting. Besides the ostrich, the American rheas, the cassowaries, the emus, and the curious apteryx of New Zealand belong to this family of ancient type, numerous representatives of which have only recently become extinct. These birds differ from all others in having no keel to the sternum, and, in consequence, are either wingless or have only rudimentary wings, and progress by running only. The leg of the ostrich is described as a wonderful piece of mechanism, capable of propelling the bird forward like a catapult. The ostrich is said to cover twenty-eight feet in its stride, and to be able to run at the rate of twenty-six miles an hour. The cassowaries are the best known members of the Struthionidæ: nine species are described, four of which come from the little-investigated island of New Guinea, where probably there remain more species yet to be detected. The use of the singular bony helmet and of the powerful elongated nail with which the inner toe is furnished, in these singular birds, can only be guessed at, as there have been few opportunities of examining them in their wild state. The Struthious birds are very similar in their habits, being for the most part hardy and able to bear vicissitudes of climate; most of them have bred in confinement in England, and they are easily domesticated. With all of them the male bird takes a larger share than the female in bringing up the family; collecting together the eggs, which his spouse drops rather at random, and either entirely incubates them, as do the emus, or as the ostrich does, sits upon them at the most important time, viz., by night. Mr. Harting has reproduced a very interesting and amusing account of the nesting of the smaller emu of West Australia in this country, which our readers may perhaps recollect appeared in the *Zoologist* for 1863 and 1864.

The ostrich used to range over a considerable portion of Central Asia, but is becoming each year more rare, and has a more restricted habitat. It is still found in some parts of Persia, in the Lower Oxus, and in the deserts to the east of Damascus, but the vast continent of Africa is to day its chief home. Here it is hunted for its feathers from Barbary to the Cape, and is found upon all level plains suited to its habits. The finest birds, producing the best feathers, are those which are obtained in the neighborhood of Timbuctoo. These feathers are exported from Tripoli, and are so highly prized that they never appear at a public sale. The South American rheas share with the ostrich the little-to-be-envied privilege of being able to contribute towards the adornment of beauty, and a war of extermination is being carried on against them for the sake of their feathers. In 1874 sixty tons of feathers, of the value of 132,689 dollars, were exported from the Argentine States alone. It is calculated that between 300,000 and 400,000 rheas are slaughtered annually. One French firm received in one year feathers worth £48,000 from Banda Oriental, Entre Rios and Buenos Ayres. We are not surprised to hear that these noble birds are fast becoming scarce. Like the ostrich, the rhea is easily domesticated, and has bred with Mr. Walter Trevelyan at Shepton Mallet, in Somersetshire, and in a park near Chippenham.

The account furnished by M. de Mosenthal of the present prospects of ostrich farming at the Cape Colony is most interesting. It was felt that if the ostrich has to be hunted down and killed in order to supply the demand for its beautiful feathers, the end must soon come in its total extermination, and that the ostrich was too noble and too valuable a bird for this fate to be permitted to overtake it. Although for more than a hundred years the settlers at the Cape had been in the habit of keeping domesticated ostriches, there had been no attempt to rear them, or to make a business of farming them for the sake of the feather market. Some successful experiments which were instigated by the French Acclimatization Society in Algiers first directed attention to the capabilities of such a trade. It was not until 1866 that domesticated ostriches bred at the Cape, and so rapidly has the practice of ostrich farming grown since that year that a census taken in 1875 ascertained that there were then in different parts of the colony no fewer than 32,247 ostriches in a state of domestication. In 1858 there had been exported from the Cape 1,852 lbs. of feathers, of the value of £12,688; while in 1874 the quantity had swollen to 36,829 lbs., of the value of £206,640, or an average value of £5 12s. per lb. Sufficient to show that ostrich farming is no unremunerative trade. It was soon found that it did not require very much to start an ostrich farm. A certain extent of ground needed to be surrounded with no very elaborate fence; crops of lucerne, the favorite food of the bird, had to be cultivated, and then, provided the soil was suitable, the ostriches did very well, bred readily in their domesticated state, and endured to be plucked of their feathers once in eight months. The chief requisite was that the soil should furnish alkalies, either in salt-licks or in the shrubs growing wild upon it. Farms supplying these conditions are in the colony termed "sweet-veldts;" those which do not are called "sour-veldts," and on these ostriches cannot be maintained in a healthy state unless they are given phosphates of lime, in the shape of pounded bones. It was found that the ostriches were in best feather at their breeding time, when it would not do to disturb their plumage for fear of interrupting their succesful nesting. Necessity therefore invented, and soon improved upon, a method of artificial incubation, which is now brought to such perfection that the eggs stand a better chance of being hatched than they would be if left to the natural care of the parent birds. It is said that out of forty-five eggs forty-three can now be hatched out with almost a certainty, and that ostriches thus artificially brought into existence are just as strongly developed as those hatched in a wild state, where there is usually much waste with the eggs deposited by the female birds. Only a part of the number produced are incubated; supplementary eggs are left lying round the nest —it is said to afford their first food to the newly-hatched chicken.

At the proper time for robbing the ostriches of their beautiful and costly feathers—fine specimens are literally worth their weight in gold—the birds are driven into a small pen, and the operation is conducted without cruelty. An eyewitness relates:

"Having got with my friend into the middle of the crowd, so packed that they were unable to move, he quietly selected two or three of the best feathers, and with a very sharp curved knife in his right hand, the blade protected by lying flat against his finger, he pressed it down as near to the root as he could, and cut it off obliquely upwards. The bird was quite unconscious of the operation, standing perfectly still as he handed several to me: he then picked out a blood feather, very beautiful, which on being cut bled a little, but the sharp knife separated it without it being felt. In a month or six weeks he took out all the stumps, if they had not already fallen out. By this means the health of the bird is not impaired, no irritation fever is produced, and you can select the feathers that are in prime condition, leaving the others that are to ripen in due course."

At some places it is the custom to pluck the feathers out, and this certainly must be painful to the birds. The finest feathers are those of the wings; a good feather is said to be almost two feet long, and from eight to nine inches wide. Such a feather would be cheap at a sovereign. By the Cape Government the wild birds are now protected by a very stringent game law. No one can kill them without taking out a £20 license, and there are heavy penalties for robbing the nests. The eggs of the ostrich have many enemies. The black crow is wont to hover over them, dropping stones until it succeeds in breaking one that it may devour its contents. Vultures have been seen walking towards an ostrich's nest with pebbles in their beaks with which to hammer at the eggs. The Bushmen carry off these precious potential feather-producers to barter them for a paltry sixpence to the collector of curiosities. And besides the winged marauders that plunder the nests, there are many human spoilers to whom an omelette of ostriches' eggs is a welcome dainty. So that there is every need to give the birds and their nests all the protection of the law in order that there may be an available wild stock to recruit the ostrich farms.

Apparently there is no limit to which the South African feather trade might not be carried, and herein, and not in the diamond fields, may be the future development of the prosperity of the colony. As far as we can see, there is only one danger to which the ostrich farmers are exposed. And that is the tendency of disease to break out amongst all animals or birds which are placed in abnormally favorable conditions for their multiplication. If in their wild state dangers have to be encountered which to a certain extent diminish their productiveness, yet these very obstacles tend to strengthen their vital force. It is said that diphtheria is apt to break out among domesticated ostriches, and as the number of these mounts up annually we are apprehensive lest this complaint may sometimes assume the severity of "an ostrich disease," to the loss and disappointment of those who are devoting themselves to ostrich rearing.

The work of which we give this short notice is appropriately illustrated with pictures of various modes of ostrich hunting, and with figures, beautifully drawn and engraved, of the ostrich, rhea, emu, cassowary and apteryx. It is just the sort or book to give as a Christmas present to a young naturalist. Had ostrich farming existed when we were young, and had such an interesting account of it, as that supplied by Messrs. Harting and de Mosenthal, been put into our hands, we feel quite certain that we should have been fired with a desire to emigrate at once to the Cape Colony in order to join in what would have seemed to us a most fascinating method of making our fortune.—*Murray A. Mathew, the Zoologist.*

November 11, 1876.

THE CHEMISTRY OF COAL.

THE first of a series of six lectures on the "Chemistry of Coal" was recently delivered, by Dr. Frankland, in the Chemistry Theatre of the Science Schools, at South Kensington, London. The subject was "The Origin of Coal ;" and the lectures, which are in connection with the Science and Art Department, are intended expressly for working men, and are delivered at 8 o'clock on Monday evenings.

The lecturer began by pointing out the importance of his subject, and, in support of this, he mentioned that there were raised yearly in the British Isles 100 to 107 millions of tons. What a mass this quantity was was demonstrated to the most unreflecting mind by the fact that a bar of coal, exceeding a yard square, would go through the centre of the earth seven times, and leave something considerable to spare; and, with reference to our future coal supply, it was stated that—on the best computation that could be made—there still remained to be got in the British Isles some 83,000 millions of tons. With these prefatory remarks, and after pointing out the position of the carboniferous system in the earth's crust, Dr. Frankland proceeded to describe the properties of the constituents of coal. Carbon, hydrogen, and oxygen were stated to make up what is known as coal, and commonly described as mineral, although—as it is nothing but the vegetation of a remote antiquity, acted upon and reduced to its present state by many circumstances which geologists can only faintly trace—it is not entitled to the name of mineral at all. Plants derive their growth from the action of carbonic acid and water; but with the latter constituent the lecturer did not this evening concern himself. He went on to say that hydrochloric acid poured upon marble decomposed it, as would vinegar if poured upon chalk, and that carbonic acid would then be produced, one of the properties of which is to extinguish flame, which was illustrated by placing a lighted taper in a jar of carbonic acid, when it at once when out, and the gas did not ignite. Carbonic acid combines with baryta, and if passed through baryta water a sediment of carbonate of baryta is produced, and this was impressed upon the audience by several experiments. This carbonic acid is heavier than the atmosphere, and can be poured from one jar into another, and the increase in weight of the latter jar was shown by the delicate balance with which the laboratory is provided. Carbonic acid gas can, by pressure, be converted into a liquid resembling snow, the temperature of which is 128° F., below the freezing point of water; this solidified carbonic acid is, therefore, able to freeze mercury, as was actually done; and in order to show that that was not all it was equal to, the lecturer performed the most popular experiment of the evening, viz.: he placed a red-hot crucible over a flame, and dipped into it some mercury; this he covered with liquefied carbonic acid and ether, and shortly afterwards removed the mercury in a frozen state, when its malleability was shown by hammering it into a rough shape.

Carbonic acid is a compound, and one of its constituents is carbon or charcoal, and this carbon may be extracted from it by heating potassium in a vessel containing carbonic acid gas, when it becomes a black substance—in fact, charcoal. Its other constituent is oxygen. Carbon is found to exist principally as—1. Charcoal; 2. Graphite; 3. Diamond.

Charcoal was proved, in the reverse way, to form one of the constituents of carbonic acid by inserting a piece of it in a state of combustion into a jar of oxygen, when it scintillated, and, on being mixed with baryta water, a white sediment (carbonate of baryta) was produced. The same experiment was also performed with a diamond, with the same result. It was explained that lime water had been used in the place of the baryta water chalk would have been produced instead of the carbonate of baryta.—*Eng. Mechanic.*

THE CANDELARIA MINE.

THE Candelaria mine, in Durango, Mexico, is one of those rich old Mexican mines, from which immense sums were taken out by the original owners who worked it a hundred years ago, but which never paid much after it fell into the hands of the American owners. This mine is owned by a New York company, who have worked it for almost 13 years but never realized anything from it, although they are now likely to do so, as ore has been struck in the tunnel, the face of which is within about 350 feet, as near as can be calculated, of the spot where the richest ore was found by the Mexicans.

It is known that upwards of $50,000,000 were taken from this mine by the old Mexicans, but during some legal difficulty the mine was temporarily shut down, and filled with water, which the Mexicans never could get out. It was finally abandoned and left in that condition until the New York company in 1863 purchased the property and commenced work. The upper works were caved in and operations have been carried on in a desultory manner on different parts of the mine with but poor success. At best the Mexican miners will only work about five days in the week, and then numerous holidays even lessen the average. Bad ventilation has bothered the company, and several times the enterprise came near being abandoned. The facilities of transportation are very bad, and articles ordered in March, for instance, would not arrive at the mine until June. The history of this mine has been like most others, worked by Americans or English in Mexico, all sorts of obstacles, unknown elsewhere, being interposed to prevent active operations.

Some work in running drifts on towards the old works has been done, but proved unsatisfactory. It was found that there was about 400 feet of water in the mine, and that such extensive caves had taken place as to greatly hinder operations. It was resolved to do most of the work on a tunnel which would drain the mine. This tunnel was originally started by the Mexican engineer, Garcia, in 1810, but it was abandoned after 125 feet had been run. The New York company took hold of the tunnel in October, 1863, and have now only got in 1,250 feet. As may be seen by this, progress has been very slow in prosecuting work.

This tunnel, however, will effectually drain the mine to a depth of 900 feet from the highest croppings, and admit of the owners' working the ore where the Mexicans quit work. From the open cut on the hill to the bottom of the old workings is about 1,000 feet in depth. The tunnel run in 513 feet and struck the vein, then followed the vein 737 feet. Small stringers have been cut once or twice, which yielded well, but advices from there just received, state that at last good ore has been struck in the heading. The 30 feet run through this ore body proves it to be no mere stringer, for it improves as entered upon. This will be good news to the New Yorkers who have waited so long for a return on their investment. It is estimated that the heading is now within about 350 feet of the center of the old mine, and the old ore body may be struck any day. The drilling is done by hand, and only two men work in the face at a time, so that progress is necessarily slow. The vein itself varies from 30 to 60 feet in width, the pay ore being mainly next to the foot wall.

We have been shown plaster casts representing the spur in which this mine is situated, and also showing a section of the mine with the old and new workings, made by Mr. Temple, father of Mr. A. V. Temple, the present engineer of the mine. Drawings, maps, etc., having failed to give the New Yorkers a correct idea of their property, these models have been made and will be sent to them. They were made from data collected by the present and former engineers of the mine—Dahlgren, Rice, and Wiedner. From these surveys sections for each 100 feet were made. Mr. Temple marked out these sections on a board, and with a fine saw cut the boards at the marks. The pieces of board were then put together and covered with clay, which made the model from which the cast of the "spur" was made. He then sawed through on a line with the vein, which gave a section of that. On the section are marked the cuts, drifts, shafts, winzes, etc. The details of old workings are somewhat indefinite of course, but a good general idea is given. The location of the tunnel is also shown. This idea is a good one, and might be followed to advantage by many superintendents, as nothing gives so good an idea of the workings of a mine as a good model made to a scale.—*Mining and Scientific Press.*

NOTES FROM ST. PETERSBURG.

AT the last meeting, October 18, of the Zoological Section of the St. Petersburg Society of Naturalists, Prof. Wagner gave some information as to his recent researches made in the Solovetsky Bay of the White Sea. The special aim of them was to throw some light on the causes which determine the use in certain organisms, as for instance the hydroids, of two different modes of reproduction, sometimes by gemmation, and sometimes with the help of special organs. Without coming to any decided conclusions (the researches having to be continued) M. Wagner pointed out, as one possible cause of this difference, the influence of different nutrition which generally so greatly influences the reproductive functions. M. Cherniaffsky, who has been many years engaged in the study of the fauna of the Black Sea, and now studies especially the influence of the media on organic forms, reported upon his numerous collections of animals from various depths, and traced in them the slow variations which animals of the same species undergo at different depths, and the appearance of new species with the increase of depth; the labors of M. Cherniaffsky promise to be of great interest when published in full.—*Nature.*

ALGOID SWARM SPORES.

IF vessels of water containing algæ are placed in a room where they are lighted only on one side, swarm pores generally are found to collect at the side turned toward the window, more rarely on the opposite side. If they are present in considerable number, they often become arranged in peculiar cloudy forms; network, rays, tree-like branched figures, etc. The phenomena has been frequently studied, and has been always regarded as an action of light, causing the living swarm spores to move towards it or withdraw from it. After a long investigation of the phenomena, M. Sachs has come to a different conclusion. He considers that these groupings of zoospores are not phenomena of life, inasmuch as quite a similar process is found to occur with emulsions of oil in alcohol diluted with water; also that the light either does not at all participate in the action, or does so indirectly, for all the phenomena may be reproduced in darkness. The accumulation of spores and the cloud-like figures are rather due to currents produced by differences of temperature in the water. M. Sachs's experiments are described in *Flora*, 1876, No. 16. —*Nature.*

THE LONDON UNDERGROUND RAILWAY.

Our engraving illustrates the new Aldgate station of the Metropolitan Railway, London, lately opened to the public. Although this extension amounts to only a half mile in length, it has involved great expense, because of the remarkable engineering works that were required; for example, the walls of some of the immense tea warehouses of the St. Katherine Dock Company, 86 ft. high and 4 ft. thick, had to be "underpinned," and deeper foundations put in for them; but this work was successfully carried out without the slightest injury to the buildings. In spite of all obstacles, the diversion of nine great sewers, and the construction of a large sewer, 5 ft. by 3 ft., beneath the rails along the whole length of the line, the works have been promptly completed. The excavations were just outside where the old City walls stood, and a few Roman relics were found. Outside the new station, 20 ft. below the surface, was discovered an immense deposit of bullocks' horns, cartloads of which were removed and sold. No other bones were with them, and how they came there in such numbers is a mystery.

There are plenty of openings for ventilation along the new line. Aldgate station is the lightest and airiest station along the line. The glass roof extends half the length of the platform; the other half length is covered by narrower roofs supported on wooden pillars rising from the platforms themselves. The front of the station is in High street, Aldgate, a door or two from the old Church of St. Botolph, and opposite to the Minories. The upper portion of our engraving shows the street front of the station building on High street.

a few months they would have twenty miles of completed road. They were negotiating for a still further extension of their routes, and would in time burrow under the whole city of London. These roads had proved to be a greater convenience to the poorer classes than to wealthy persons. The average fare collected was five cents, and the rate per mile was reduced by a system of commutation to one penny. These roads carried 70,000,000 passengers a year. Heavy locomotives were used, and 1,000 trains per day, each having a carrying capacity for 1,000 persons, were run over them. The rate of speed was very great. The cost was $5,000,000 per mile, of which about four-fifths was due to damages to real estate caused by cutting through blocks of buildings and tunnelling under houses. In some places the roads ran under graveyards without disturbing the graves and the vaults above.

This enormous cost for land would be wholly saved in New York, because here the railway lines would be longitudinal with and run directly under the main streets, without invading private property. But in London, owing to the formation of the city, the underground roads pass athwart the streets and cut through private property in all directions. The citizens of London have ascertained by practical experience that the underground system is the best, have invested in it upward of eighty millions of dollars, and are annually increasing the investment and extending the works.

Sir Edmund said that 93 per cent. of the passengers on the London underground roads travelled only short distances, and only 7 per cent. of them were carried to the end of the various routes.

From these experiments it will be seen that the strength is increased in an enormous proportion by the process of cold rolling. This increase in strength may be and probably is to some extent only apparent, and due simply to the fact that the iron is more condensed. Thus if a bar $1\frac{1}{4}$ in. in diameter was rolled cold until it was reduced to $1\frac{1}{8}$, this reduction in diameter is due in part at least to the fact that the metal is condensed by the rolling, and that a bar of say $1\frac{1}{4}$ in. diameter and any given length may not weigh any more than one $1\frac{1}{8}$ in. diameter of the same length. The cross section of the one would, however, be nearly $1\frac{1}{4}$ square inches, while the other would be one square inch. If then each broke at a strain of say 60,000 lbs., the one would have a strength of that much per square inch, while the other would have a strength of only 48,000 lbs. per square inch. In other words, there might be the same quantity of iron in each case, the only difference being that in the one case the material occupied less space than in the other. From experiments which have been made, it is obvious, however, that the increased strength is not due to this cause, or at least it is so only to a very slight degree.

NEW ROAD LOCOMOTIVE.

Messrs. Marshall, Sons & Co., of Gainsborough, Eng., have lately introduced the type of engine of which we give an engraving, and the following particulars from *Engineering*:

In designing the engine under notice Messrs. Marshall have acted on the principle that the boiler should be not

THE RECENT EXTENSION OF THE UNDERGROUND RAILWAY, LONDON.—THE NEW ALDGATE TERMINUS.

Entering there the visitor passes by easy steps down the landing seen in the lower part of the engraving, thence by the stairs to whichever platform he desires to reach. Our illustration is from the *Illustrated London News*. The situation of the terminus is most convenient, and will bring the company a large amount of business. Within a short distance are the London and the St. Katharine's Docks, Fenchurch and Leadenhall streets, the Commercial road, and the densely populated neighborhoods of Whitechapel and Towerhill. Thus the eastern extremity of the City and the best business parts of the East End, will be brought within a few minutes' journey of Holborn and the west end of London, the Great Northern, Great Western, Midland, and Chatham and Dover Railways. The increase in the fares to Aldgate will only be a penny per ticket. All the trains of the Metropolitan Railway Company will run through to the new station, except the Great Western main-line trains, which are few in number. A marble tablet in the Aldgate station records the fact that this extension of the Metropolitan Railway was commenced on March 1, 1876, and gives the names of Sir Edward Watkin, chairman of the company, and his fellow-directors; the general manager, Mr. Myles Fenton; Mr. Brady, the engineer; and Messrs. Lucas and Aird, contractors.

During Sir Edward Watkin's visit to New York, a few months ago, he gave some very interesting particulars concerning the operation of the rapid-transit railway system of London.

The London Underground Railroad Companies, he said, already had about sixteen miles of road in operation, and in

IRON SHAFTING EXHIBITS.

Jones & Laughlin, of Pittsburgh.—This old and well-known firm occupied a large space in Machinery Hall, in which they exhibited the various articles which they manufacture. Their exhibit commenced, it may be said, from the beginning, as they exhibited coal from their own Pittsburgh vein, coke made from their Connellsville vein, iron ore from Pennsylvania and Missouri from which they manufacture pig iron, of which they also exhibited specimens. Next came specimens of a great variety of merchant bar, angle and strap iron, light rails from 8 to 40 lbs. per yard, street rails from 23 to 45 lbs. per yard, cut nails, railroad spikes, fish plates and bolts of various patterns, some of them of the recent single and double bracket patterns, boiler rivets and all kinds of bolts and bridge irons.

The most interesting part of their exhibit, however, is that of their "cold rolled shafting." This is made from $\frac{3}{8}$ to $4\frac{1}{2}$ in. diameter round, and from $\frac{3}{8}$ to 2 in. square. The process of manufacture is to take a good quality of bar iron, and by subjecting it to the action of acid to remove all the scale from the surface. It is then run through rolls while cold and is thus reduced in diameter from $\frac{7}{16}$ to $\frac{1}{4}$ in., according to the size of the bar. The effect of this seems to be to solidify or condense the metal, and probably also to stretch it. Its strength is certainly increased, as is shown by some experiments made by Wm. Wade of the United States Ordnance Department, a summary of which is published by Messrs. Jones & Laughlin in their circular.

merely partially, but entirely, independent of the engine proper, and that it should be capable of being readily removed for examination or repair without interfering with the engine or gearing. In other words, they desired that the boiler and engine should stand in the same relation to each other as they do in an ordinary railway locomotive. With this object in view they have provided their engine with a complete frame, this frame carrying the cylinder, the plummer blocks for the crank-shaft and counter-shaft, the bearings for the driving axle, the fore-carriage, the water tank, coal bunkers, etc., while the boiler which is fixed to the cylinder at the smokebox end is at the firebox end merely connected to the frame by brackets which slide on the frame and thus allow the boiler to expand freely.

The frame consists of a pair of frame plates suitably connected by transverse stays, the cylinder being fixed to these frame plates at the front end under the smokebox, as shown in our engraving. The engine we illustrate has a single cylinder $8\frac{1}{2}$ in. in diameter, with 10 in. stroke, there being fixed by the side of the cylinder a feed-water heater through which the feed water is pumped on its way to the boiler. The cylinder is steam-jacketted, and special provision is made for draining the jacket of water. The guide bars are supported by a motion plate or transverse stay at about one-fourth their length from their rear ends, the guide bars passing through this plate and being of such length that they are slightly overrun by the crosshead. This arrangement, which has lately been much adopted in locomotive practice, enables the guide bars to be made shorter and stiffer, and at the same

time enables the crosshead to be drawn out when required, without disturbing the bars. The motion plate just mentioned also carries the weigh-bar bearings, and the bracket for the governor.

The crankshaft is carried by plummer blocks fixed to the frame plates, a flywheel being mounted on it at the left-hand side of the engine. This flywheel is so situated that it can be got at by the driver in the event of the engine stopping on a centre, but if the engine is properly handled this rarely occurs, and we have seen one of the engines we are describing worked about a yard with a load for a considerable time, stopping in and starting from awkward places without there

accessible, and the steam is led down to the cylinder by a steam pipe in the smoke-box as in an ordinary railway locomotive. The boiler exposes 129½ square feet of heating surface, while the fire-grate area is 4.9 square feet. The blast nozzle is kept low and carefully set in the proper position in relation to the chimney so as to insure a good draught with a large area of nozzle, this being a point in which ordinary portable engine practice is very defective. The boiler of the engine under notice is well stayed and the fittings are neatly arranged.

The feed water is carried in a tank at the hind end of the frames below the footplate, and the fuel in coal bunkers on

6 in. beam, and is rigged as a fore and aft schooner. The accommodation on board is ample, comprising a large saloon, state room, etc., forward, and crew's cabin and store room aft. The engines are high-pressure condensing, with three cylinders and injection condenser; the high-pressure cylinder is 13.5 in. in diameter and the two low-pressure cylinders are 15 in. in diameter, the stroke in each case being 16 in. The boiler is of Bessemer steel of the locomotive type, with copper firebox and brass tubes, the working pressure being 100 lb.

The speed guaranteed by the contractors was 18 miles per hour on a run of two hours, and this speed was easily maintained with a boiler pressure of 60 lb., and from 248 to 250 turns of the screw per minute. Upon the trial run, however, a far higher speed was recorded, 43 miles having been run in 1 hour 48 minutes 22 seconds, equivalent to 23.89 miles per hour. The boiler pressure during this run was 100 lb., the vacuum averaged 24 in., and the horse power developed was about 450, the mean number of revolutions being 318 per minute. This large increase of speed on that guaranteed, was a matter of considerable importance to the contractors, who received a premium on each mile made during the trial run above the 18 miles guaranteed. It is needless to say that Messrs. Thornycroft have fully maintained their reputation by the remarkable results above recorded.

THE WORTHINGTON PUMPING ENGINE.

OUR illustration shows the construction and arrangement of the large Worthington engine which was exhibited at the Centennial. It was one of the most powerful operating examples of steam machinery exhibited. The *Engineer* says of it:

The task of supplying the Exhibition with an adequate quantity of water for all purposes was no light one. It should be borne in mind that the area to be supplied comprised 236 acres, covered with buildings which were crowded during the day, and provision had also to be made for an ample supply at a high pressure in case of a fire breaking out, the consequences of which would have been most disastrous if it were not checked at the outset. In order to put the water supply of the Exhibition on a proper footing, the Commission secured the services of Mr. Frederick Graaf, formerly the chief of the water department of the City of Philadelphia, and this gentlemen designed and laid out the whole of the Centennial Waterworks. The source of supply is the same as that of the larger quantity of water supplied to the city, namely, the river Schuylkill, and the intake is situated near the Belmont landing, where passengers for the Exhibition disembarked from the small river steamers which ply above the Fairmount Dam.

A neat brick building, ornamented with patterns and a real slate roof, the latter being a very uncommon feature in America,* contains the engines and boilers not yet removed; the chimney also of brick work, surmounted with an ornamental iron cresting, is 80 ft. high. The grounds around the pumping station are neatly laid out and kept, and the fountain playing in front of the door of the engine house was a refreshing sight in the midst of the torrid "Centennial" summer. The engines themselves were supplied free of cost to the Commission by Mr. Henry B. Worthington, of New York, and it is to be regretted that this, one of the best and largest engines in the Exhibition, and the only one of any magnitude except the Corliss engine, and one which was continually performing actual work, should have been placed in such an out of the way corner of the grounds, where it was seen by a very small portion of visitors; but as the river would not come to the engine, the engine was obliged to go to the river.

The pumping machinery consists of what most people would call a pair of direct acting steam pumps, but which is described by the inventor as "one Worthington duplex compound pumping engine," capable of raising from five to six million United States gallons of water in twenty-four hours to a height of 200 ft. The main feature of the invention is, that although the machine consists of two separate and complete direct acting pumping engines, the steam valves regulating the movement of each individual engine are operated by the other, so that the two engines become, in fact, one pumping machine, neither engine having the control of


NEW ROAD LOCOMOTIVE. BY MARSHALL, SONS & CO.

being occasion to touch the flywheel at all. The flywheel is also so placed that a belt can be led off from it to a thrashing machine, etc., well clear of the leading wheels, while the crankshaft can also carry a smaller pulley, from which a mortar mill or other machine requiring a slower speed can be driven.

Of course when the engine is employed in driving a thrashing machine, etc., the road gear will be thrown out of action. This is effected in the usual way by sliding the crankshaft pinion on the crankshaft. This pinion, when the road gear is in use, drives a spur wheel on an intermediate shaft, this wheel having cast on it a pinion gearing into the main spur wheel on the driving axle. The latter axle is driven through

each side of the footplate. The feed water is, as we have said, warmed by forcing it through a heater on its way to the boiler, this heater being traversed by the exhaust steam, and being so arranged that the pipes through which the exhaust steam passes are quite free to expand and contract, while the whole can be very readily taken apart for cleaning. A tool box is provided between the frames at the leading end.

The general appearance of the engine is very neat, and we think that Messrs. Marshall, Sons & Co. are decidedly to be congratulated on the results of their bold departure from ordinary practice. The details of the engine have been worked out with much care, and the proportions are good and substantial throughout.
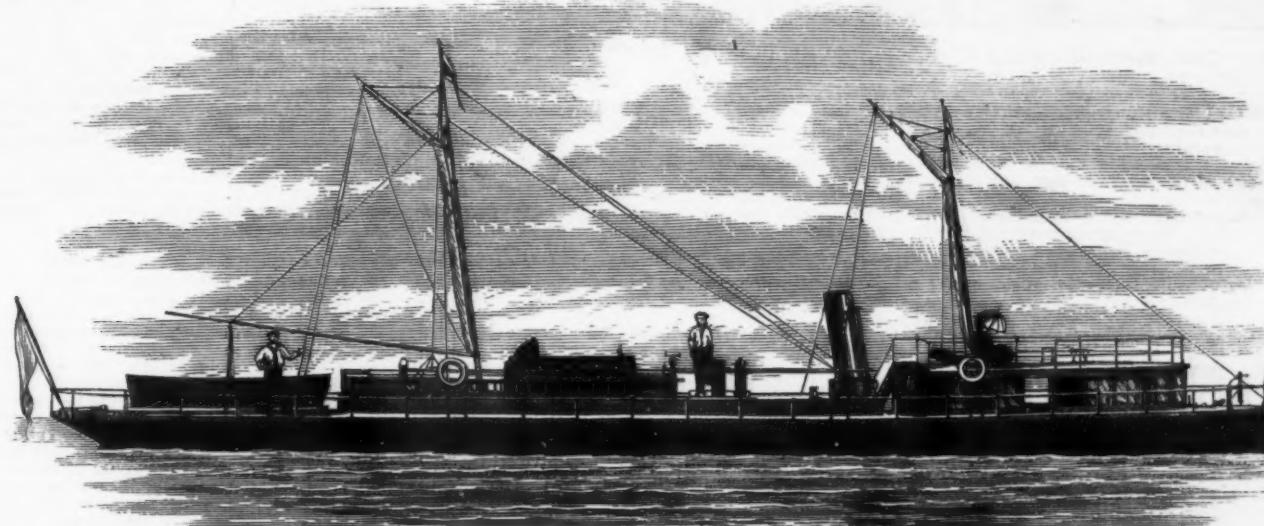
THE STEAM PLEASURE YACHT "GITANA."

compensating or "jack-in-the-box" gear, this gear being made very strong, and its details being exceedingly well worked out so as to give ample bearing surfaces. The driving wheels and leading wheels are both of wrought iron and of neat design, the former being provided with an efficient brake. The fore carriage is all of iron, and it is situated under the cylinder, as shown in our engraving.

The boiler has a flush-topped firebox casing and is without a steam dome, the steam being collected by a perforated pipe extending from end to end of the boiler, and communicating with a stop valve case fixed to the smoke-box tube plate above the tubes. The stop valve is arranged so as to be readily

THE STEAM YACHT "GITANA."

WE publish an engraving, from *Engineering*, of the steam launch Gitana recently built by Messrs. John I. Thornycroft and Co., of Chiswick, Eng., for the Baroness A. de Rothschild, and intended to run on the Lake of Geneva, where she was sent in pieces, there not being sufficiently good navigation on the Rhine to take it to its destination by water. We have heretofore published in our SUPPLEMENT an account of the remarkable performances of this little steamer, said to be the fastest boat in the world; and we now give its dimensions. The Gitana is built entirely of steel, is 91 ft. long and 18 ft.

its own valves. The result of this arrangement is, that any amount of time may be allowed for the repose of the piston at the termination of each stroke. The water valves can thus come quietly to their seats, the currents can subside, and equilibrium of pressure be formed without the noise and hurtful shocks which follow all attempts to force these results by the uniform reciprocation of a piston connected with a fly wheel. The two pistons are never at rest at the same time, but one or the other is constantly exerting its full effect upon the water column, preventing it from coming to a state of rest in the main, and insuring a constant delivery.

* The writer is evidently unacquainted with our extensive uses of slate.

One object sought by Mr. Worthington is that the rate of movement of the water column through the forcing main should be as nearly as possible uniform.

The Cornish engine is defective in this respect, being single acting and intermittent, and the stream delivered by one of these engines varies enormously in volume, rendering a stand pipe almost a necessity. Rotative engines also deliver a very unequal volume even with the combined bucket and plunger pump, owing to the variation in the speed of the piston, as the crank approaches to and recedes from the center.

Another improvement effected by Mr. Worthington is to reduce the weight of moving parts to a minimum, and thus reduce their momentum.

The Cornish engine is very defective in this respect, depending, as it does, upon the descent of a heavy weight to move a column of water, and in rotative engines the heavy fly wheel revolves with almost irresistible force, compelling currents to change their direction suddenly, and valves to beat into their seats with more or less violence. Engines should also, if possible, be compact and self constrained, and not require the costly engine houses and massive foundations which are requisite for Cornish and rotative engines. There can be no question but that Mr. Worthington has obtained all the advantages enumerated above. The buildings are small and inexpensive; the engine house only measures 45 ft. by 38 ft., and is large enough to contain another engine of the same size as the one now in it, and with ample space to spare for auxiliary engines for boiler feeding and other purposes; the engine room is only one story high, and the engine is quite independent of the walls. There is a total absence of noise or concussion; in fact, with the eyes shut, it is impossible to believe that you are standing alongside of an engine of such large power. The best proof that can be given of the uniform pressure in the delivery main from one of these engines is shown by a card taken in the same manner as an indicator diagram, from the delivery pipe of a Worthington duplex pumping engine of 5,000,000 gallons per day pumping capacity, at the Belmont Water-

works, Philadelphia. I have a photograph of this card before me, and it shows no rounded corner or waving connecting lines, thus proving the perfect seating of the valves after every stroke, the complete filling of the chamber for every stroke, and the practical uniformity of motion of the water column. Economy is another important consideration, and in this respect the Worthington engine stands high.

A table prepared by Mr. Worthington, and based upon the official reports of the various corporations as to the quantities of coal burnt and water pumped, gives the average annual duty of forty Cornish and rotative pumping engines as amounting to 33,223,359 lbs., the highest duty being obtained from a Cornish engine at Jersey City, which gave a duty of over 52 millions, and the lowest from a beam and rotative engine at the Philadelphia Waterworks, which only performed a duty of 17,162,896. The latter was also a beam and rotative engine, and must be an exceedingly bad specimen of that type. As compared with the above, the duty is given of twenty Worthington Duplex engines, which give an average duty of a trifle over 48 millions, the highest being 57,819,552, and the lowest 38,680,990. One of these engines at Newark is stated to have performed the duty of 77,358,478 lbs., of water raised 1 ft. high with 100 lbs. of coal.

The dimensions of the "Centennial" engine are as follows: Diameter of high pressure cylinders, 29 in.; diameter of low pressure cylinders, 50½ in.; stroke of piston and pump, 50 in.; diameter of pump plungers, 22¼ in. One of the air pumps has a diameter of 30 in., and the other a diameter of 27 in., the stroke of each being 24 in. The working speed of the piston is 110 ft. per minute, and the guaranteed quantity of water is lifted at this speed. The workmanship of the engine is excellent throughout, and the details which strike the eye of the English engineer are too numerous to mention.

The general arrangement of the engine will be readily understood by reference to the engraving, but the details of the valve gear, by means of which one half of the engine regulates the movements of the other half, are too complicated to be described without many detailed drawings, although to look at the mechanism is extremely simple. The whole of the cylinders, steam pipes, and chests are carefully lagged all over with wood, and every precaution taken to

prevent the loss of steam by condensation. One striking peculiarity is the long dome over each valve chest, which is introduced to enable the slide valves to be suspended from the end of a long bar, and to oscillate like a pendulum, and thus prevent all pressure on the valve faces.

In the boiler house are two boilers, also constructed by Mr. Worthington, and each of 6 ft. 6 in. diameter of shell, and 18 ft. long, and containing ninety-six 4 in. tubes. They are worked with a maximum pressure of 60 lbs., and an ordinary working pressure of 50 lbs.

A high pressure auxiliary engine and pumps have been provided for temporary use, capable of raising to the necessary height one million gallons in twenty-four hours. A small duplex engine is also engaged in feeding the boilers.

The pumps take their supply from a large well in the engine house, which is fed from the river through about 75 ft. of 30 in. main, guarded by the proper screens at the inlet on the river and in the well. The ascending main is 18 in. in diameter, and 958 ft. long, from the pump to the stand pipe. The latter, situated near the park drive, northward of Memorial Hall, is made of wrought iron, 4 ft. in diameter and 120 ft. high from its base, with a finial 13 ft. high surmounting it. For a height of 25 ft. above the surface of the ground it is supported by masonry, of octagonal form, faced with green serpentine, with mouldings, roof and dressings of Ohio sandstone. The water was pumped into this pipe to a height of about 208 ft. above the level of Fairmount Dam, and about 108 ft. above the floor of the main Exhibition building. From the stand pipe a 16 in. main extends about 1,300 ft. to a 'point on Belmont avenue northward of the Main and Machinery Halls, where it reduces to 12 in.; from this latter were supplied the three mains underlying Machinery Hall, and three similar ones under the floor of the Main Exhibition Building. Connected with these pipes, inside and immediately outside of the two buildings just named, are no less than 126 fire hydrants. Mains also extend to Horticultural and Agricultural Halls, and to the Government and other buildings scattered about the grounds; the whole length of the mains connecting and within the various buildings exceeds

six miles. The total number of fire hydrants in the various buildings, and within the Exhibition enclosure, is about 300. The 10 in. main, which supplies the lake at the north of Machinery Hall, does so through a fountain consisting of three concentric rings of jets of 50 ft., 30 ft., and 12 ft. in diameter, from which will issue about 200 jets of water.

Connections were also provided between the City Waterworks and those of the Centennial Commission, to enable them to mutually assist each other in case of necessity.

The works reflect great credit upon the engineer, Mr. Graaf, and upon Mr. Worthington, for gratuitously supplying the engine and boilers.

FITTING KEYS AND KEYWAYS.

By Joshua Rose.

No part of the construction of a machine is of more importance than its keys, and there is probably no part the quality of workmanship of which can be so generally taken as indicative of the quality of the workmanship on the machine throughout. Keys, proper, are divided into two classes—the locking and the adjusting key. Those used for fastening gears to shafts are a sample of the first, and those used with gibs are specimens of the second. In addition to these, however, there is a third kind which is stationary to its seat, and this is called a feather. It is generally sunk in, and sometimes rivetted into the shaft.

A locking key should fit the keyway a good sliding fit on the sides, and tapered top and bottom, for the following reasons: The object of such a key, applied say to hold a gear-wheel to a shaft, is to lock the wheel firmly to the shaft, and to keep it locked. To do this in spite of the great strain and continuous vibration, a great deal of pressure is required; furthermore, the pressure must be of a nature that will yield a trifle without becoming lost. Now, if the sides of a key alone are depended upon to lock such a wheel, the assistance rendered by the key is very small indeed, for the sides cannot well be made tapering, and a very tight fit cannot well be made on the parallel sides of a key, and even were it otherwise, the metal of the key compresses, even though

it be of steel. Such a key would soon become loose, and when once it gets the least play its destruction is very rapid, even if imbedded to the shaft so that it cannot come out, as it is otherwise sure to do. If we take a key ¼ inch square and say 4 inches long, the area on its sides acting to lock the wheel will be equal to one square inch only, and even on this there will be neither strain nor elasticity. If, however, we give such a key taper top and bottom, and drive it home a proper fit, we shall have, in addition to the inch of indifferent and inelastic detaining area on the side, an inch of area on the top, and this inch it is that is the locking surface. The advantage of such a key will be perceived when we remember that its sides being a good fit, and the key driven lightly to a seating, all the rest of the distance that the key is driven is elasticity, which will serve to accommodate the compression of the metal as well as more firmly locking the wheel. Such a key, it is true, at once shows bad workmanship when the same is present, and is hence dreaded by the inferior workman. If a wheel is not a proper fit to the shaft, the key will tell the tale by setting the wheel out of true. Now, suppose a feather instead of the key were used, the wheel would still be a bad fit, though its defectiveness were hidden.

To fit such a key properly, it should be planed or milled on the sides and on the bottom face, then the sides must be filed true to a surface plate, and fitted into the keyway in the shaft, so that it can be slid up and down a good working fit. While fitting it, however, it is well to try it once or twice in the keyway in the wheel, as well as in the shaft, so as to see by the marks whether the keyways in the shaft and wheel require any fitting at all, either to make them quite square with the outside face, supposing it to be turned off; or to give them a good even bearing surface. The key being fitted sideways we must give the two keyseats a coating of red marking just sufficient to show that the surface is of a red tint, and then put the wheel in its place on the shaft. Then we bevel off the edges of the key at each end, leaving a chamfer of ¹⁄₁₆ inch, and after facing off the top of the key with a bastard file, we place it in the keyway and tap it very lightly to a gentle bearing. It is here that crude workmen are apt to commit an error by driving the key in too tight during the fitting processes, and the result is that the key springs to a fit and bears marks of the marking where it should not. After driving the key lightly home and taking it out again, we may file it on the top and bed it on the bottom, according to the indication of the marking, and reinsert it, tapping it up until it is home, top and bottom, without being a driven fit at all; on taking it out we file it according to the marks again, and if we continue this process until the key is a good fit, it will not spring the wheel the least out of true, no matter how tight, reasonably, it is finally driven. The key must never be driven in or out dry, for it will, in that case, inevitably cut during the first part of the operation; the marking put on the keyway is sufficient, but after two or three insertions the key also should be itself given a light coat, which will serve as lubrication, as well as to denote the fit. In the case of an old keyway, it is as well to fit a piece of wood thereto as a guide in forging and fitting the key. If a *fast* running grindstone or emery wheel is at hand, many will forge the key a trifle large and then grind it as near as possible, and finish by filing. This, however, does not produce good work; it is better to plane the key all over, leaving a little in size for fitting. In preparing the piece of wood referred to, it should not in the fitting be driven or even forced in and out to try the fit, for the wood will compress and the marks will mislead as to the actual fit. The proper way is to chalk the piece of wood and push it up the keyway just tightly home, then withdraw and fit it again.

In cases where the key is forged to very nearly the finish, and is finished by the file, as sometimes occurs when away from the shop, it is best to forge the key with a jib head to assist in extracting it, especially when it is difficult to drive the key out from the back end, or when the keyway does not pass entirely through. The key should be finished with a smooth file and with the file marks lengthways; it is, in fact, better to use a small smooth file or draw file, taking care to ease the high spots the most, and before driving it home, both it and the keyway should be oiled.

In fitting a feather to a shaft it should be filed dovetailed at the ends, and a neat fit at the sides. After the seat is cut in the shaft to nearly the proper length and width, we take a chisel set, and set back the metal all around the sides of the keyseat, which will cause a swell all around the outside. We then fit the feather and put it into its place in the shaft, with the dovetail face downwards, and, taking a set, close the swell down around the feather, which will make it a tight fit on the sides, and by the dovetail at the ends lock it in its seat. If the feather is to be fastened in a bore instead of on a shaft, we file on the sides of the keyway in the bore a dovetail countersink at each end, and then rivet the end of the feather into it.

The bore for a key is made to drive on the shaft, while the bore, where a feather is used, may be made a working fit. The feather requires no taper, and for many purposes is accompanied by a set screw, which is always used if any locking is required.

The taper should be left in the keyseat in the bore, and not on that in the shaft, because if the keyseat is slotted, the spring of the slotting machine tool will give in all cases a certain amount, and very often sufficient taper to the key way; and bearing this in mind, the work should be bolted to the slotting machine table with the back end of the keyway next to the table face, for it is at and towards the bottom end that the slotting tool springs away from its cut. The reason that the slotting machine tool leaves this taper is as follows: There is, when the tool strikes its cut, a certain amount of force springing the tool away from the cut, and if we suppose in the first inch which the tool travels, it springs the one hundredth part of an inch only, the second will have another one hundreth, and so on as the tool descends. Now it is true that the angles of the slotting tool may be made to obviate this spring, and that its amount depends largely on the shape of the tool; but, nevertheless, such shapes of tools as are usually employed will cut the keyway taper, and if it is required that it be parallel, the slotting machine must be let run a little time at the finishing cuts without giving the tool any feed.

If the keyways require to be cut out with the hammer and chisel, we may cut the taper in the shaft or the bore as circumstances may render the most desirable. To chip the seat in the shaft, we mark it with either a V marking piece or from the end face of the shaft (if it is trued up) with a T-square, and taking a flat chisel cut down the shaft level to, very nearly, the lines. Then take a cape chisel and run the cuts down each side, nearly close to the lines, taking out the middle (supposing the keyway to be wide enough to leave one) with a flat chisel. In performing these operations we should hold the chisels firmly against the cut, as though try-

THE WORTHINGTON DUPLEX COMPOUND PUMPING ENGINE.

ing to push the cut off, and if cutting wrought iron we may apply the edge of the chisel occasionally to a piece of oiled waste. Both the cape or crosscut, and the flat chisel will work best kept pretty thin at the point and ground not too keen. In filing at the keyway, first ease out the corners with the edge of a half round file, and use a piece of surfaced metal or the key itself to surface the keyseat with. In chipping out the keyseat in the bore, great care is necessary to keep it straight, and it is better to keep a little inside of the lines.

The sides as well as the bottom should be surfaced true, and the corners kept just clear. If the keyway is in cast iron or brass, the cut must not be cut all the way through from one side, or the metal at the end of the cut will break out, and even in wrought iron this is apt to occur, so that it is necessary to cut the keyway from each end, or, at least, nick it in at one and cut it from the other end. In long keyways it is handiest to cut them half way from each side, using, in the absence of anything better, a piece of planed wood and red marking or chalk to try the keyway with. On many lathes there are attachments for cutting the keyways after the holes are bored; and this is an excellent plan, because the keyway is, in this event, sure to be true with the bore. Very small keyways are often cut by a cutter fastened to a bar fitting the hole in the work, the bar being forced through the work by a press, or it may be driven through by a hammer. If the cut is too great to be taken at one cut two cutters may be used, one following the other, either in the same or in a separate mandril. The advantage of this plan is that the work is sure to be exactly uniform both in width and depth, and it is a great deal quicker than the most expert hand work. In this case, however, all the taper must be on the shaft.

The keyways for adjusting keys such as are used with gibs and straps, as upon connecting rods, etc., require very careful treatment. In the first place the keyways in both the strap and the rod, or stub end, as it is often called, must be filed out both together, and the strap must therefore be bolted or clamped to the stub end. It will not, in this case, do to set the keyways fair, or to attempt to adjust them after the strap is clamped, because by such a procedure we shall only spring it, and when the keyway is finished and the clamps are removed from the strap, it will spring back and no longer be true with the keyway in the stub end. To prevent this, care must be taken to set the strap in its exact right position, and as fair (by the keyway) as necessary before tightening the clamps on the strap. Having set the strap, the clamps must be screwed up evenly and regularly, so as not to move the strap. If the strap should get accidentally moved, he must slack back the clamp before readjusting. In filing the keyway we select an ordinary flat bastard file with a safe edge on one side, and if it has not one, we must grind one. What is known as a parallel file should never be used if an ordinary one can be got in, because parallel files are, as a rule, very uneven upon their surfaces, and file the keyway rounding. In any event it is a good plan at first to chalk the file teeth, and after a few strokes the marks will show in what parts the file teeth touch, and the workman can govern its use accordingly. All these keyways should be surfaced to a surface plate, and cannot be made a good job of any other way (unless it be in the case of small keyways, by drifting them as hereafter explained). Many a keyway that has not been trued to a surface plate looks a good fit when it really is anything but that, for the workman takes care to make each side of the keyway hollow, so that it shall look well from the outside. The surface plate should mark the keyway surface even all through, and the diameter should be parallel. The finishing should be done with a smooth file, and if the file is warped at all, and in fact, in any event, the finishing should be done with the thin end of the file where it has plenty of curve. Then we can be sure to apply the file just where it is wanted without touching any other part. The corners should be eased away a trifle with the edge of a half round file. For filing out the edges of the keyway a file with both edges safe must be used, and if one is not at hand we may improvise one by grinding the teeth off on two opposite sides, taking care to look down the file to see which are the most twisted or warped faces, and preserving the rounded ones. For roughing out, a taper square file is best, but for finishing a parallel file should be used; and here it may be as well to state that the reason that a parallel file should not be used on the side faces of the keyway is that a flat parallel file springs from the pressure applied to it, and hence will file rounding; whereas a square or a round file, being stronger, will not spring. The edges of the keyway should be made parallel one with the other, so that in fitting the keys and gibs, whether old ones or new, we can put them together and make them parallel on their outside edges, and thus ensure that they fit without driving them in and out so much to adjust the fit. It is better, however, in any event, to try them once at least to ensure their bedding properly. If the edges of the keyways are rounding, as they are sometimes made where strength is required in the strap, it is better to take a file nearly or about ⅛ inch larger in diameter than the width of the keyway, and grind two safe edges on it, otherwise the round file is very apt to go astray. The edges, as well as the sides, require surfacing true. In fitting the keys, they must be tried with and trued to a surface plate, and made such a fit that they will slide through under a slight hand pressure. In driving them in and out to fit, care must be taken to keep either marking or oil on the key, and the end of the key must be kept bevelled off, so that it will not burr up in the driving out, for which purpose a strip of copper or lead should be employed. If a key should gripe in the keyway the best plan is to pour into the keyway, from both sides, a liberal supply of oil, and then to drive the key back and forth a little way and a few times, and the oil will work in when the key can be driven out.

Small keyways are cut out most readily and uniformly by using drifts, which are pieces of steel with teeth filed in them. The holes are roughly cut out to nearly the size, and the drifts are driven through to finish them. The manner of making and using these drifts is explained and illustrated on page 300 of Vol. 33 of the SCIENTIFIC AMERICAN.

ARMY FLYING MACHINES.

EXPERIMENTAL trials were carried out at Chatham, Eng., recently, under the directions of the members of the Royal Engineer committee, for the purpose of testing the adaptability of employing "parakite" flying machines for reconnoitring purposes with an army in the field, as proposed by the inventor, Mr. J. Simmons, aeronaut. The machines may be described as gigantic kites, the largest of which had a surface area of 25 feet square. The wind had a force of between four and five, with velocity of about ten miles an hour, and was, therefore, highly favorable for the trials. Each of the parakites is composed of the best French cambric, covered over with a mixture of birdlime and indiarubber, which

has the effect of rendering it as nearly as possible air tight. From the extremities of the square are light poles, placed on sockets, which spread each parakite to the required area. The first parakite sent up was about eight feet square, and this soon rose to the required height. The desired altitude being obtained, the parakite was fastened to another of the same description, but somewhat larger in area. A third and a fourth parakite, each larger than the other, were sent up, the highest at this time soaring to a height of about 1,200 feet. Unfortunately, at this juncture, the pole of the fourth parakite snapped, and, after a failure in fitting another, the disabled parakite was removed, and arrangements at once made for raising the largest of the parakites, which had an area of between 600 and 700 square feet. But before this last parakite was sent up, a trial was made of the lifting powers of those already elevated, when it was found that they had lifted a drummer boy with ease. After a brief interval the largest parakite was attached, and was soon soaring to a height of several hundred feet, a dozen sappers of the Royal Engineers holding on to the ropes, the four parakites having a strain calculated at a little short of a ton. Captain M. T. Sale, one of the instructors in field fortifications, promptly made the trial of the lifting powers of the parakites, and was instantly raised by the ropes several feet from the earth. Almost immediately afterwards the rope holding the parakites gave way from the immense strain, and the whole came to the ground. After a brief interval a trial was made alone of the largest but one of the parakites, the largest having been placed hors du combat, when it raised a bag of sand, weighing half a hundredweight, to a great height. This terminated the trials, which were so far satisfactory that they suggested how a party might be raised to a moderate height, to enable them to watch the manœuvres of a hostile force.

SUBMARINE ROCK DRILLS.

By EDWARD MOORE, Portland, Me.

A, the rock to be drilled; b, the drill; c is the pipe by which the steam, as, or compressed air, or other medium, is conveyed to the engine f, the upper end of it being connected to the proper apparatus upon the vessel h, from which the motive power is supplied. This vessel may be anchored at any convenient point near the work to be done.

The stand is represented as located upon the rock. The shaft of the drill b, which is of a length suited to the depth of the hole to be bored, extends upward through the shield k. This shield covers such of the working parts of the drill and engine as would be exposed and liable, when in operation, to injure the life-line of the diver. The weights are marked l, and are attached to the legs of the stand in such a manner as to be readily connected or disconnected.
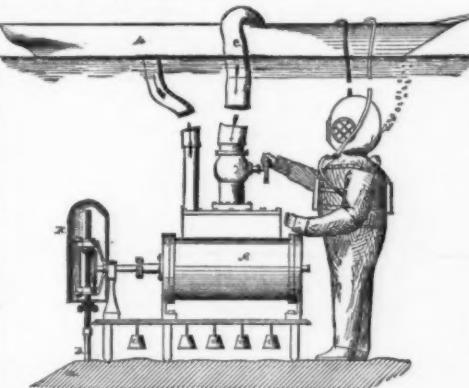
The whole apparatus, that is to say, the tripod or stand upon which the engine and drill are mounted, is sunk to the bottom and located by the divers upon a place where the drilling is to be performed. The drill should be adjusted before lowering, so as to extend no lower than the legs of the stand. The divers arrange the stand so as to rest firmly upon the rock, and if its own weight be not sufficient to cause it to rest firmly, they add the weights provided for that purpose. The drill being adjusted and the connections previously made between the engine and the motor on board of the vessel, by turning suitable valves below, the engine may be started. One hole being drilled, by reversing the engine the drill is withdrawn, in the ordinary way, and the divers, taking hold of the stand, may move it for the purpose of boring another hole, and so on in succession. The engine and working parts of the drill being wholly beneath the surface, the apparatus remains undisturbed in whatever condition the surface of the water may be, provided the vessel containing the steam generator or compressor remains in its place.

THE RELATIVE VALUE OF BLOWS AND PRESSURE.

A TREATISE on the above subject has been recently published by Professor Kick, of the Prague Polytechnic, with diagrams of the results of some careful experiments. He mentions the numerous alterations of form in materials effected by a power acting either quietly and constantly, or by means of blows, calling special attention to the forging, by means of hammers, in contrast with the Haswell press forge, to coining with the old stamp and fly press, instead of the Uhlhorn machine or hydraulic presses, to the fabrication of rod iron in the old forges, before the introduction of the modern rolling mills; and to the boring of stone with jumpers in contrast with the revolving diamond cutters of the present day. A glance at the above examples shows that the appliances, acting by means of blows, belong to an earlier age, and are undoubtedly more simple in construction than those whereby a quiet and suitably applied pressure executes the same, and ofttimes a better, work with advantage. It is not too much to say that the science of modern times is striving to replace the mechanical power exerted by blows by one acting by pressure. The foregoing illustrations show that a mechanical power, acting by blows, can be advantageously replaced by one acting by pressure, and that the labor expended in shaping materials under a quiet pressure is less than that wasted in using blows. The word pressure is here intended to comprise tension, deflection, crushing, breaking, pushing or torsion.

The work of shaping, be it stretching, shortening, bending, tearing, breaking, &c., amounts to bringing the smallest particles of any body, or a certain portion of them, into a different relative position. Every movement of the smallest

particle, which by an alteration of form must alter its relative position, will meet with a certain amount of latent resistance. Let us now suppose exactly the same alteration of form produced by a quiet pressure and by a blow, the latent resistances are overcome equally in both cases, therefore the amount of work done in each must also be equal, i. e., the mechanical effect produced by the apparatus acting by pressure must be equal to the percussion effect or vis versa required of the tool acting by blows in producing the like result. This ideal demand cannot, however, be fulfilled, because the blow must always produce condensation of the direct impinging and impacted surfaces, and vibrations which have nothing to do with the actual intended alteration of form, hence considerable mechanical effect is wasted. If, for example, we allow a weight to fall on the centre of a bar of iron supported at both ends, there will follow not only a certain deflection of the bar, but also a compression of the outside strata which come into immediate contact with the blow, and consequently an often very perceptible increase of heat. The mechanical equivalent for one unit of heat is well known to be 424 met. kilogrammes. There results then by a comparatively small increase of temperature a large loss of effort, and, in consequence of depression caused by the blow, also a considerable waste of percussive effect, intended for the alteration of form. To this must be added the almost unavoidable vibration of the supports. We admit that a blow fulfils an immense duty when a rigid substance has to be divided. One might say that the splitting of a block of stone in the usual way with wedges driven in with sledge hammers requires a very small amount of effort compared with what would be necessary to break the block by means of a load acting by pressure. This admits of explanation. By splitting a block with wedges, only those particles which lie in the line of rupture require to be affected to obtain a separation of the same, while the whole block remains unaltered; whereas if a rupture be produced by weight acting by pressure, it will not be confined to the line required alone to be affected, but will be attended by expansions and contractions in every particle of the stone, of which the greater part would be useless, if not detrimental.

Redtenbacher's "Principles of Mechanics" says: "The advantage, therefore, of separating stone by wedges lies in this—that a certain vis viva acts only just on those portions which must be separated one from the other, whereas by crushing, the whole body is affected unnecessarily."

Professor Kick, without disputing this, says: "The same effect can also be produced without the application of blows," and instances the use, for the same purpose, of blocks of wood saturated with water, and freezing water, also the breaking of glass by first heating and then plunging it into cold water; and then asks, "If an equal result be not obtained with less expense of labor, and still without a blow?"

Quoting again from Redtenbacher: "The driving of a pile into the earth without the use of blows is, so to say, a practical impossibility. If one were to try to press a pile into the ground in any way whatever, enormous preparations and precautions would be required—either one must place a weight on the pile which would nearly equal that of a house, or if one intended to effect the sinkage by a press, the press would require first of all to be made as fast to the ground as the pile itself would be when sunk; whence one must presuppose that that which is to be already exists." Kick answers: "Here too, for the sake of 'useful effect of blows,' the argument is carried a little too far." And proceeds: Without mentioning that screwing piles into the ground is both easy and advantageous, so much is certain, that the power of pressure necessary to sink them cannot be spoken of otherwise than as exorbitant. Let us take the example of a house four stories high resting on a single row of piles 3ft. apart, centre to centre, with the usual thickness of walls, according to the Building Act of Bohemia, and we find that the loading of each pile equals about 25 tons. Certainly no one will maintain that a pressure of 25 tons is no longer to be obtained. If, for instance, a pile driving vessel or in driving land piles, a wagon be loaded with this weight, the necessary pressure can be brought into effect in either case. Even if a double or treble security be required, that is, that the piles shall not sink any further under a weight of 50 or 100 tons, the application of such a weight is not accompanied by insurmountable difficulties.

In loose earth (sand) Captain Liernur, and later, others have obtained brilliant results by means of a thin pipe along the pile from whose orifice, in the neighborhood of the toe, a thin but powerful stream of water issues, which clears away and presses upwards the fine sand, and so facilitates the sinkage of the pile. Considered in this light, then, it appears very questionable if the use of blows in driving piles be attended with any advantage.

It certainly happens in the erection of works that a heavy body is moved, or in other words brought into position, by blows, and on account of its simplicity will always here and there be used. In this case, however, the mechanic must be quite aware that a certain amount of work which should be employed in moving, &c., is lost—i. e., is converted into disintegration and heat, and that the lever windlasses are always more effective where they can be applied. As blows used in moving masses are attended by a waste of labor, on account of part of the efforts, accumulated in the substance inflicting the blow, being lost in disintegrating and heating, so when applied to alteration of form they always suffer a diminution of effect by compression of the outside strata, and the conversion of work into heat to a much greater extent than when a quiet and constant pressure is applied. It may be asserted that a fair comparison between the effect of blows and continuous pressure cannot be made, because the alteration of particles is quite different. In many cases this is true; nevertheless, in other and very numerous cases—e. g., the bending of axles, coining, &c.—we may ask with good reason what the quantity of effect is for the same amount of deflection, stamping, &c., when blows are used as the power, or when pressure. For such cases we have stated that, generally speaking, the expenditure of effort for the same effect is less with the application than that of blows. The above assertions were proven by a series of experiments.

IT is stated that the finest specimens of wheat exhibited at the Centennial Exhibition came from Australia, some samples weighing 67 pounds to the bushel. California and Oregon came next.

IT is estimated that, in England and Wales, there are over 120,000 individuals engaged in grinding grain, selling grain, or manufacturing or dealing in some manner with the product. In this class are numbered millers, bakers, pastry cooks, and dealers in corn, flour, etc.

LESSONS IN MECHANICAL DRAWING.
By Prof. C. W. MacCord.
SECOND SERIES.—No. III.

IN Fig. 16, several errors are illustrated. At *A* we have a standing bolt, in which the screw-thread is indicated in the manner shown in Fig. 8, but in dotted lines because the bolt is hidden. In theory this is all well enough, but the thread be-

And finally, at *E*, we have a bolt with square head and nut; the nut is in the correct position, but the head is not, and the bolt is dotted through the nut. This last circumstance is the most serious fault; it is proper to dot the outlines through the hole through which the bolt goes; but it is manifestly incorrect to indicate in any way a hole of that size through the nut. Were anything to be done at all, we might in this case, without impropriety, show the screw-thread as was

to repeat the process. Nor have we any objection to the reader's doing this. There are probably some who have already such a knowledge of the principles of drawing, and such an acquaintance with details of machinery, that they may correctly think it not worth their while to repeat the examples selected by us, for the mere sake of the practice, but may nevertheless feel that in regard to the manner and style of making their drawings, the hints which we furnish may be of value to them. Those who are in this stage of
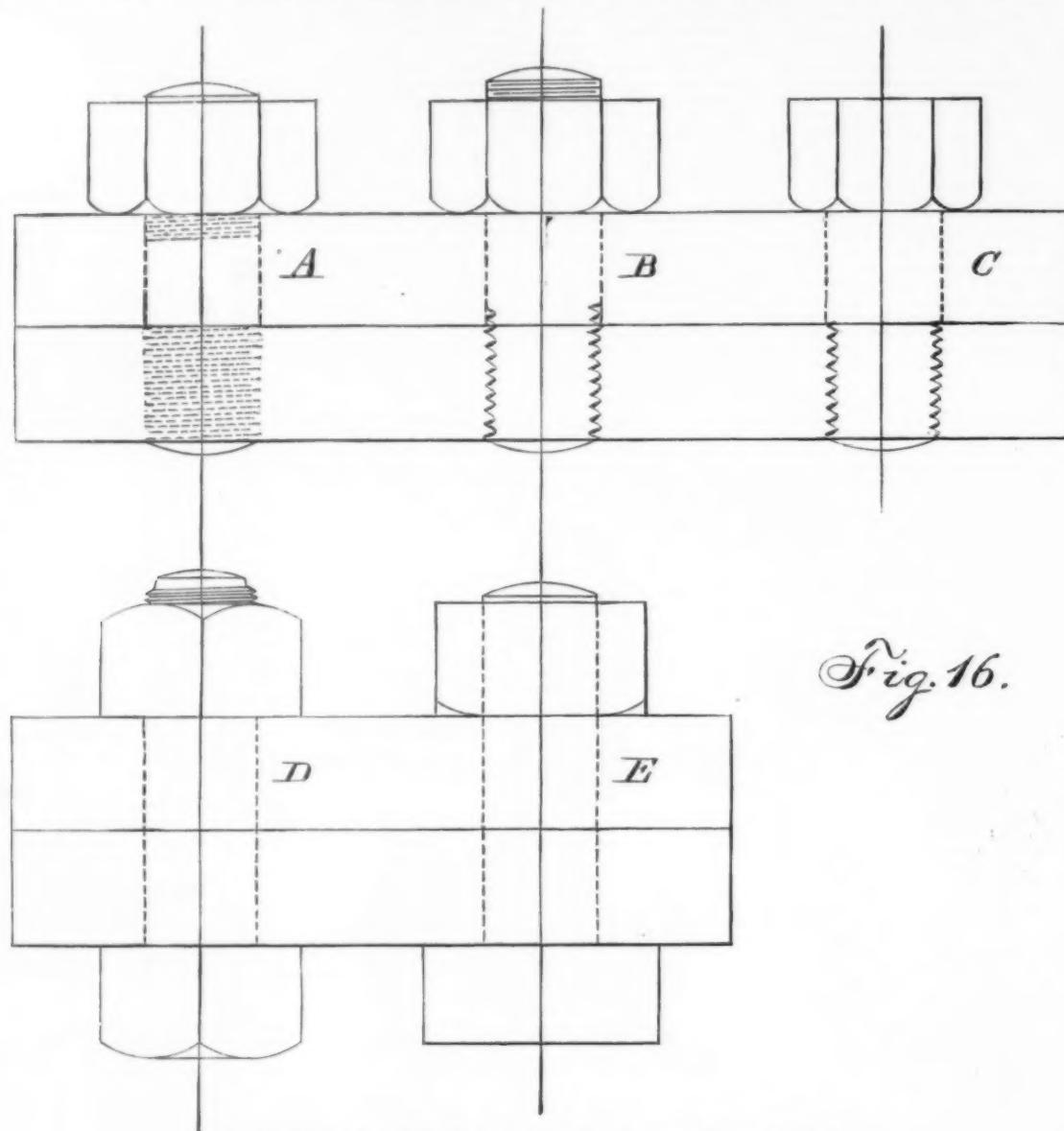
Fig. 16.

LESSONS IN MECHANICAL DRAWING. SECOND SERIES.—No. 3.

comes a mere mass of dots, and utterly fails to look like a screw. Also, the upper end does not project beyond the nut, and the curve of the rounded top alone being visible, the impression at first glance is that of something riveted over. At *B*, the thread of the lower part of the standing bolt is continued too far, and so is the upper part of the bolt itself, which projects

done at *A'*, Fig. 9, because there being no lines on the side of the nut, no confusion would arise; but this is unnecessary, for the reason before mentioned.

We now find ourselves surrounded by an embarrassment of riches, for the details of which different machines are made up are so numerous and so varied, that it does not

advancement may very properly and very profitably pursue for themselves the course above indicated, selecting either some piece of mechanism which they may have the opportunity and desire to examine and to draw, or some of the abundant and excellent examples of good work furnished week by week in this paper, making applications, in execut-

Fig. 17.
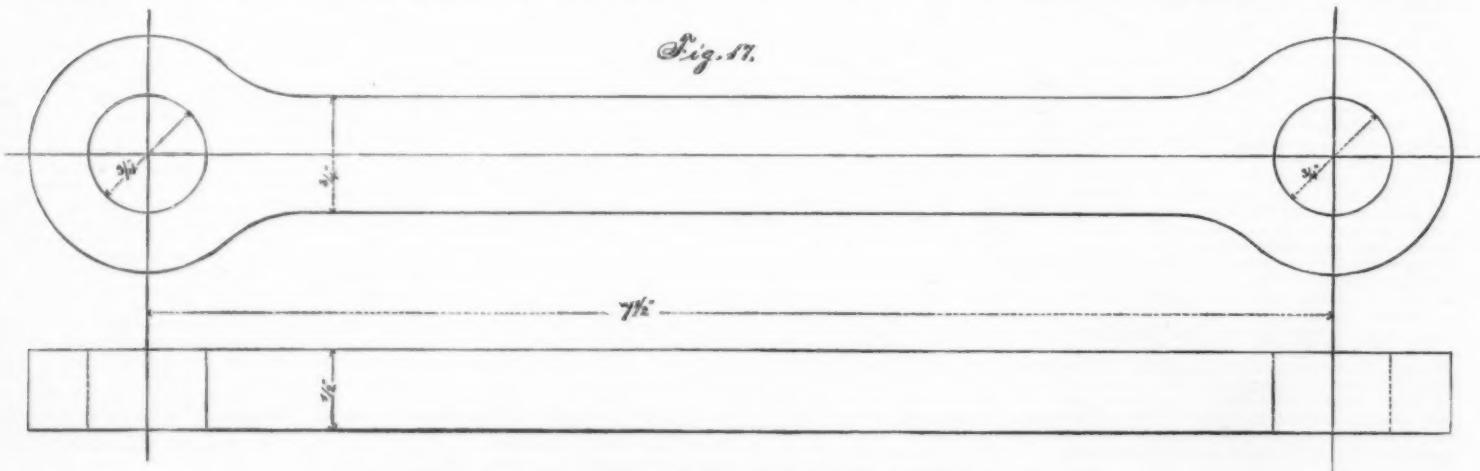
LESSONS IN MECHANICAL DRAWING. SECOND SERIES.—No. 3.

unnecessarily beyond the nut. At *C*, we have what should be a tap bolt, but the thread terminates abruptly at the joint line, just where it ought not to, but where that of *B* should. At *D* we have a bolt with a six-sided head, and nut of the same form; but this fact is not positively indicated by the drawing, since the corners are turned toward us. The top of this bolt also terminates in a curious way, for which we never have heard any excuse assigned, the thread being turned off for a short distance, and the little knob thus formed left there, so that one is reminded of "the great Panjandrum himself, with the little round button at the top."

seem easy to tell where to begin to the best advantage. Cranks and shafts, bed-plates and pillow-blocks, links and levers, wheels, cams, connecting rods, cylinders, pistons, valves, and a hundred other things crowd around, each one ready to sit for his portrait, and each one with some claim to be considered the first comer.

Under these circumstances, it might appear a logical order of exercises to take up some simple piece of mechanism and consider its parts separately in their order, making a series of drawings in detail, then a general plan, and so pass on to the examination of another and different one, with which

ing their drawings, of the principles and methods which in our instructions may be found suitable to the case in hand.

But for the benefit of others we prefer to adopt a different course, at least at the beginning, though finally it will in any event be necessary to do just what is above suggested, in illustration of the actual planning of mechanism.

What we propose is substantially this: to select some element of extended and various application in machinery of different kinds, and first familiarize ourselves with the modifications rendered necessary by varying conditions, and also with those adopted from other considerations, such as

convenience, cost, or the taste of the designer. In this way we shall gain practice in drawing, just as well as in any other way, and by making a sort of special study of such problems as may present themselves, shall be saved the necessity of diverting our attention to them when a new form or modification of this element may be met with as an item in any special machine.

Such an element, fortunately, it is not hard to find. On examination we see that every machine is composed of a series of moving parts, so connected that when one part moves according to a given law, the other parts are compelled to move according to certain other laws. Whether this constitutes a full definition of the word machine or not may be a question or a fact, just as the reader chooses to consider it; but at any rate it defines the composition. Naturally, we trace the motion through the series in order: one piece moves the next, that the third, and so on. Thus we may remove all but the first two and consider their action on each other. Of these the first, which moves, is called the *driver*; the other, which is moved by it, is called the *follower*. Now these two either touch each other or they do not; a pair of toothed wheels illustrates the first case, a pair of pullies the second. In the first the motion is transmitted by direct contact, the tooth of one wheel pushing that of the other; a pawl and rachet-wheel, a cam and roller, are other familiar examples. In the second, the motion is transmitted by an intermediate piece,—in the instance quoted it is the belt; in other cases which will readily occur to the reader a chain or a cord is used, but in all we observe that the motion of the intermediate piece is of no consequence, except in so far as it serves the purpose of transmission. It

link is jointed, and therefore are not shown in this figure. In Fig. 18 we have a somewhat similar link, but one end is formed into a jaw, which is to embrace the end of the lever, and the pin forms really a part of the link, in connection with which it is accordingly shown. This pin is in the form of a tap-bolt, one side of the jaw being tapped to receive it. But it differs from an ordinary tap-bolt in this, that it is not intended to bind anything together; it would evidently not do to have it screwed up so as to spring the jaw, as the end of the lever would thus be squeezed, and friction would result; and also it is clear that this pin ought not to unscrew and thus work out. For these reasons the pin is threaded only to a distance equal to the thickness of the side of the jaw, and the distance from the termination of the thread to the under side of the head is such that when the thread "bottoms," being screwed hard in, the bolt-head does not yet quite touch the outside of the jaw. All this is indicated in the drawing, as the screw-thread terminates abruptly at the side of the jaw, and "daylight" is seen under the head of the bolt; minutiæ which should be carefully attended to when this arrangement is adopted. The thickness of each side of the jaw, it would abstractly seem need be only half that of the body of the link, but it is better that it should be a little greater.

Around the point *a* describe an arc with radius *a c*; then the arc *b d* should not intersect the first arc, and it will be all the better if as shown its centre (which is on the prolongation of *c b*), is so far to the left that the two arcs are not even quite tangent to each other.

Since the head of the bolt does not bear against a surface, but is merely used for turning the pin, it may be quite small,

And a word as to the colors themselves. It is possible to buy red ink and blue ink in bottles; but it is advisable not to. All the colored inks we have ever seen have a chemical action on both pen and paper. The former ruins the instrument by corrosion; the latter renders it difficult to erase when necessary. It is better to use water colors, and for our present purposes we have never seen any thing better than carmine and Prussian blue. The cake of color should be wrapped in tin foil, leaving a sixteenth of an inch exposed at the end, which may be rubbed in the saucer, and then carefully wiped dry with a bit of soft paper; if this be not done, the water will be absorbed by the cake, and the cake thereby disintegrated; this is especially true of the carmine, which is extremely friable. If any small particles crack off while mixing the color, which is very likely to occur, they may simply be rubbed with the finger until the whole becomes perfectly smooth, as these colors are entirely soluble.

They should not be mixed as thick as they will flow from the pen, for if they are, the color will appear dull; indeed, Prussian blue will run from the pen when so thick that the line will look nearly black. A clear, decided, and brilliant tone should be aimed at, and may be attained by two or three trials.

It may happen that while it is desirable to use this mode of securing the pin, on account of convenience in putting the mechanism together or taking it apart, there is not room for the projecting head. In such case the expedient shown in Fig. 19 may be adopted; the jaw is tapped and the pin threaded as before, but the latter is cut off flush with the front of the jaw, and a slot is made in the end, so that it may be turned by means of a screw-driver.

Fig. 18.

Fig. 19.
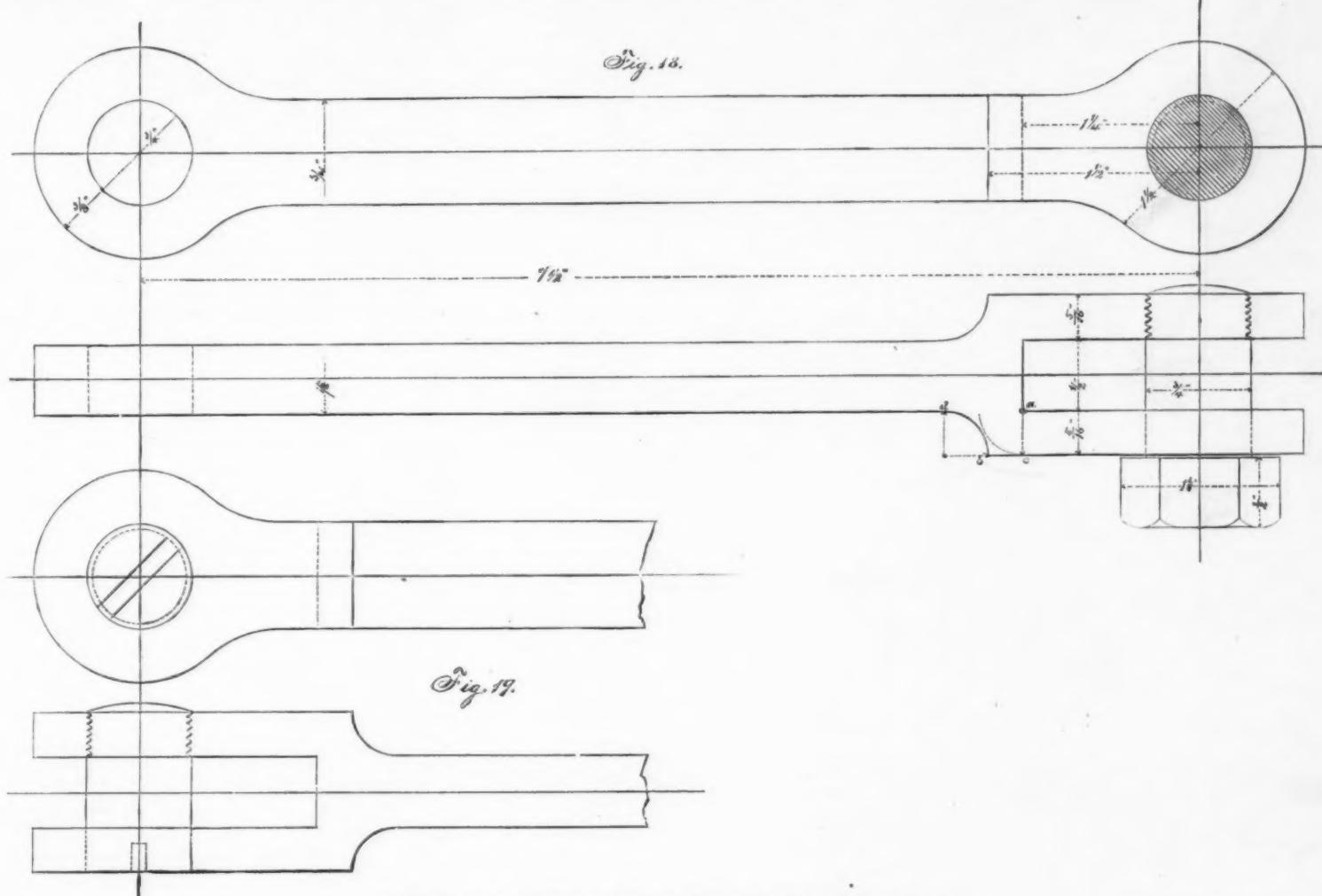
LESSONS IN MECHANICAL DRAWING. SECOND SERIES.—No. 3.

is not the motion of the belt, but the motions of the pulleys, that interest us. But a cord or a belt can only pull, and is not able to transmit motion in both directions; yet in many cases it is necessary to do this, so that a flexible connector can not be used. We must, then, use a rigid one, jointed to the driver and to the follower.

This rigid intermediate piece is called a *link*, in treating of mechanical movements in the abstract, and in practical mechanism it is called a link if small, a connecting rod if large, though in truth these terms are rather relative than otherwise. However, it is enough that we fully understand what is meant; and examples will readily occur to the reader in which such connections are used in various ways.

The simplest form of a link, evidently, is merely a flat bar, with an eye at each end through which to insert a pin. This is shown in Fig. 17, which is a complete working drawing; since the piece is fully and clearly defined by the two views given, the end view is not drawn, and a moment's reflection will show that it would convey but little information if it were, and that in a very unsatisfactory manner. This point the reader is advised to commit to memory; there is no fear that the draughtsman will be thought unable to make a special view because he omits it. We are inclined to think that this is one reason why many introduce unnecessary views of what they are drawing; they know that three projections are often needed, and seem to fear that if they do not always make them some one will think they do not know how. Well, if some one does, so much the worse for him; it is tolerably sure that the workman will not, for if he can understand from the views he has just what he is to make, he will be satisfied, as he should be, and will not waste time in pondering on how another one would look, or whether any one else knows.

Now, in Fig. 17 the link alone is drawn—the pins are supposed to belong to the levers or other parts to which the

and its *top* corners, instead of the lower ones, may be rounded off. In the upper or side view the bolt is best shown in section, as though it had been cut off flush with the front face of the jaw; a circle being dotted inside the outline to indicate the bottom of the thread.

We may here state, that in making detail working drawings, it is better to use different colors for some purposes, instead of making everything in black. Thus, centre lines will be much more conspicuous, and less likely to be confounded with the outlines, if they are drawn in red. And when anything is shown in section, it is well to use distinctive colors for different materials.

These colors need not be of the exact tint of the material shown; in fact they are purely conventional, and one system will do as well as another if it be once agreed upon. We may say then for the guidance of those needing it, that in many of the leading shops it is customary to section cast iron in black, wrought iron and steel in blue, brass and copper in red. Our pin then being of wrought iron or steel, would be shown in blue. Also, the lines upon which dimensions are figured, should be *dotted* in red; in many cases they are made full lines, but the effect is very bad, as the centre lines are overwhelmed by them, and the general appearance of the drawing gives an impression of haste and lack of finish.

We know the counter argument by heart, "What is the use of spending the time in dotting all those lines?" To which we reply, that under some circumstances there is time to make first-class detail drawings, and we intend to point out how to do it, leaving it to the common sense of our readers to determine when the time cannot be afforded. And this is one of the things which have a most emphatic effect upon the finish of a plan; if the reader wishes to ruin the appearance of a finely executed drawing, he can do it with the utmost facility and dispatch by putting in the "dimension lines" full instead of dotting them.

Probably it will occur to the reader that this is suitable in small machinery only; still it is employed, and the figure is introduced mainly to call attention to one point in the drawing; which is, that the depth and breadth of the slot are shown in the top view, just as though the slot were vertical, while in the side view the slot is shown at an angle of 45°. This is done simply in order to avoid having the two parallel outlines, which are quite close together, also parallel to the center line, as they would be if the slot were there shown in a vertical position. It will be seen at once that it can make no possible difference in what direction this slot really stands or lies; nor can it make any whether it be shown in the same position in the two views or not. Consequently we select the positions which will make the drawing clearest: a proceeding quite in accordance with the object for which the drawing is made, although it is a departure from the rigid rules of projection. We repeat, that we are now aiming at a practical result, to show what to make and how to make it; and we shall have frequent occasion to point out that this result is not always to be attained by blind literal obedience to the rule of representing an object invariably in the same position.

But it is not always possible, even if it were always desirable, to use a link so simple in form as either of those above described. The part to which it is connected may be of such construction that it is necessary to make the link in parts, so that it may be put together over the pins. One end of a link thus made is shown in Fig. 20, and to prevent any misunderstanding, the separate parts are shown in Fig. 21; we may also remark in passing, that it will do the novice no harm to copy them, although Fig. 20, by itself, is a complete working drawing. A piece called a strap, *A*, is fitted over the end, *D*, of the rod, or link; there is a slot, *s*, through the latter, and corresponding slots, *r*, *r*, in the sides of the strap, permit the introduction of a gib, *B*, the hooked
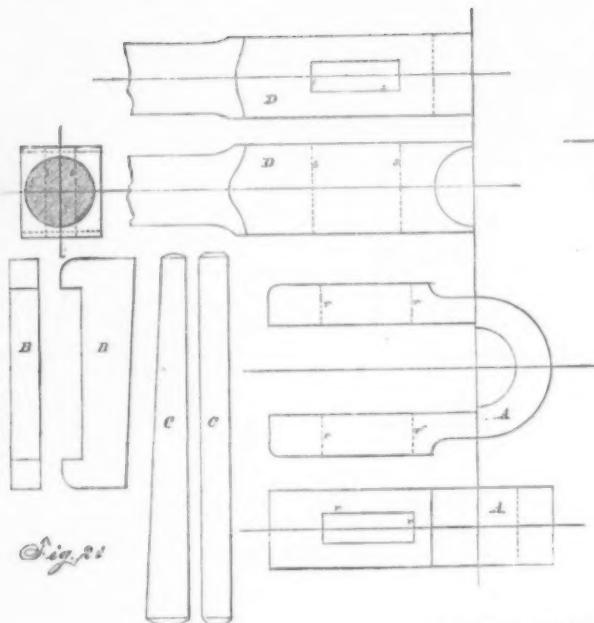
Fig. 20.

Fig. 21.
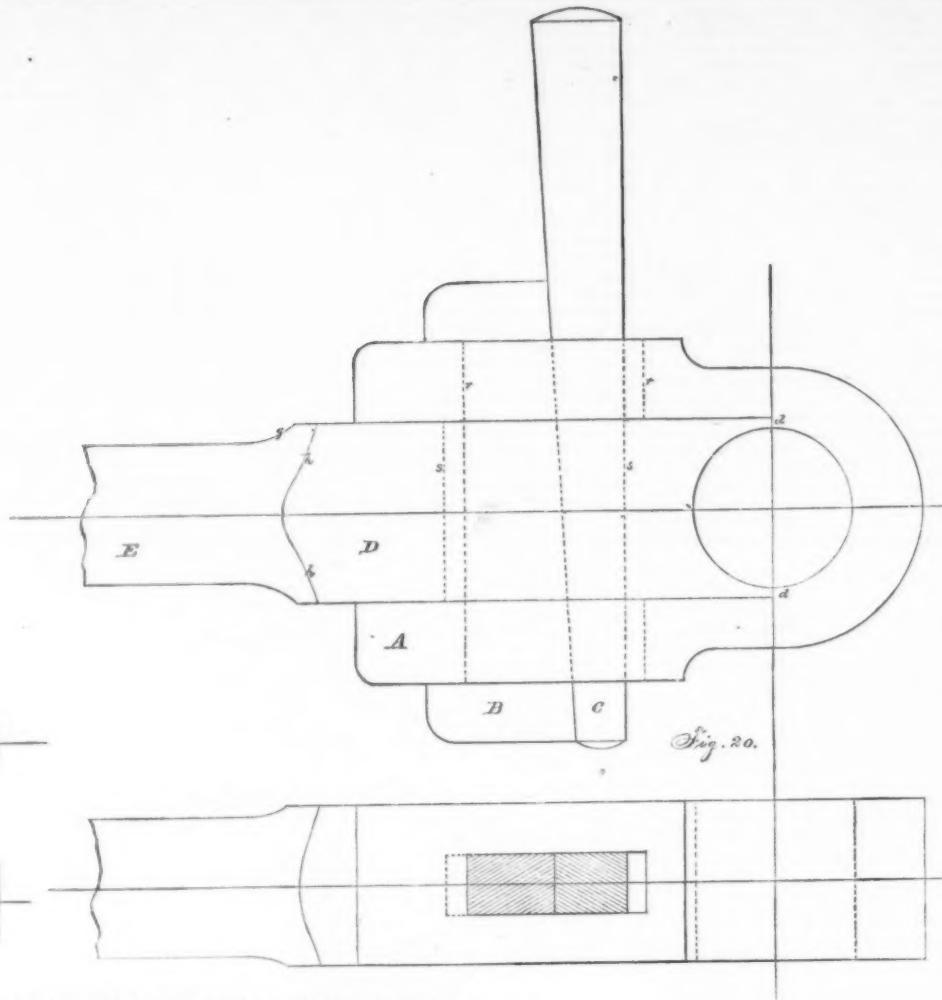
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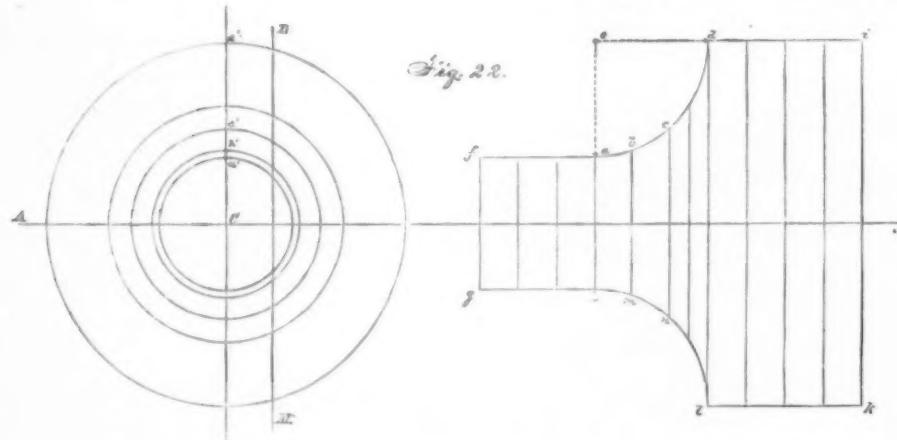
Fig. 22.
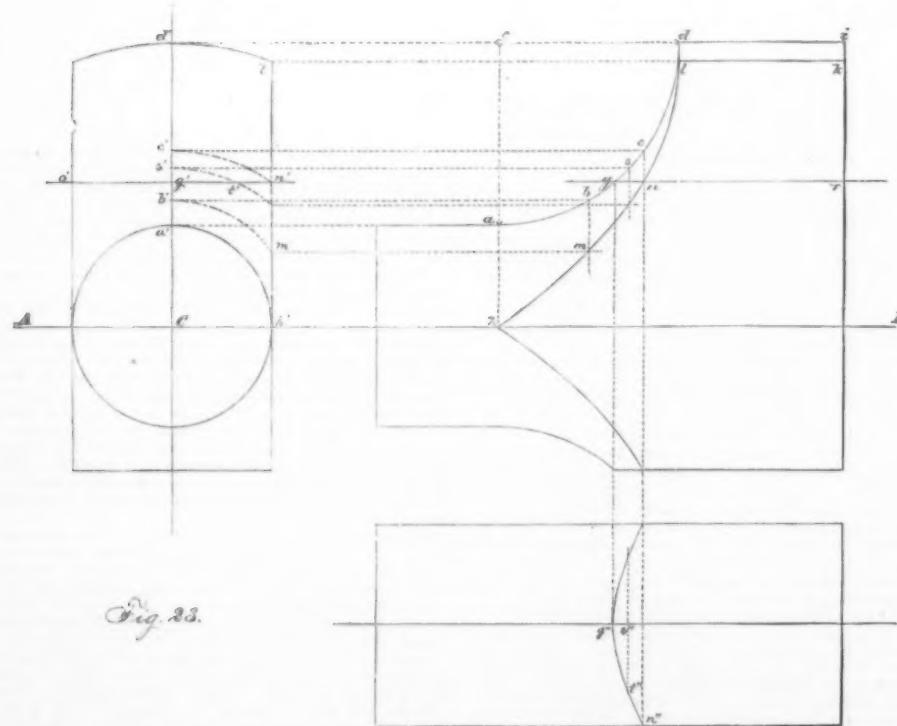
Fig. 23.

LESSONS IN MECHANICAL DRAWING. SECOND SERIES.—No. 3.

ends of which fit over the strap, holding its sides together, and this is driven home by a tap-r key, C, thus binding the whole into substantially one piece, through which the hole for the pin is made, half in the "stub end," D, and half in the strip. It will be noted that when put together, the slots, s and r, do not exactly correspond, but, as seen in Fig. 20, the key bears against the right-hand side of the former, the gib against the left-hand side of the latter, so that on driving the key down, the strap is drawn bodily to the left by the gib. No dimensions are figured on these drawings, which may be copied of the size shown. Our object is to illustrate the general arrangement of the parts, and to call attention to one or two special points. It will be observed that the breadth of the stub end, D, is greater than the diameter of the pin; this is in order to have a positive bearing surface, as shown at d, d, where the strap meets it; were the breadth of D no greater than the diameter of the pin, we should have mere knife edges at those points, which clearly would not do in practice. Again, the neck, E, of the link, is cylindrical, whereas the stub end is of a rectangular section, and the manner of finishing the rod, in order to pass easily and gracefully from one form to the other, is worth making a special study, as it presents a problem of very frequent occurrence, and its solution furnishes an interesting problem in the intersections of surfaces.

In Fig. 23, if the outline f a b c d i, be supposed to revolve about the axis A B, the result will be the formation of a smaller cylinder, f a h g, and a larger one, d i k l, joined by a solid, a d l h, shaped like the mouth of a trumpet. It may be as well here to define the expression, revolving about an axis, in order to have it clearly understood when used hereafter, as it frequently will be. An axis, then, is a right line, and another line is said to revolve about it, when every point thereof describes a circle of which the plane is perpendicular to the axis, and the centre in the axis. Thus the points f, a, describe circles f g, a h, whose planes are perpendicular to A B; these circles are seen in the end view, their radius being O'a'. Also d and i describes circles d l, d k, seen as such in the end view, the radius being O d'; so of b, c, and all other points in the outline. A line thus revolving generates a surface called a surface of revolution; it is, in short, a surface which may be formed in a turning-lathe. If we split such a surface from end to end by a plane through the axis, the section thus made is called a *meridian section*, and its outline is obviously the same as the generating line. But in the case now under consideration, the surface is cut by a plane parallel to the axis; just as if we were to turn up a piece of wood of the form shown, and then flatten it by planing. Such a plane is shown by the line S M in the end view of Fig. 23; and an idea of the result may perhaps be formed by imagining the solid to be made up of a number of thin slips or veneers, as indicated by the transverse lines a h, h m, etc., in the side view; each of these slips will be turned into a circular form, and a piece will be cut off the side of the circle by the plane S M; and the length of the chord will be the same in both the side and the end views. The operation of constructing the curve joining the ends of these chords in the side view is shown in Fig. 23. The meridian section, or extreme outline, f a d i, is as before composed of the lines f a, d i, parallel to the axis, joined by the circular, are a b c d, tangent to f a, whose center is e, but the plane, seen in the end view, as i k', is tangent to the smaller cylinder generated by the revolution of f a round the axis A B. Now, the circle described by d, of which d' l in the end view is an arc, is cut by this plane at l' in that view, which in the side view will appear at l, on the same level, and perpendicularly under d, the line d l being in fact the side view of the arc d' l. So, also, s' m', an arc of the circle described by s, is cut at m', whence we find m in the side

view in the same manner; this also is a point in the required curve, h m n l, which by repeating this process may be defined with any required degree of precision. Since a' h' is tangent to t' h' at the point h', the upper branch of the curve will terminate at h, and since the surface is symmetrical, the lower branch will be like the upper, but in the reverse position. But, to form the stub end of our connecting rod, we must cut the surface by another plane, also parallel to the axis, but perpendicular to the first, as shown by g r in the side view, n' o' in the end view. The intersection of this plane with the first will be the right line n r; but its intersection with the surface will be a curve, seen in the front view as g n, in the end view as g' n'. In making a connecting rod or link, it is important to determine the point n, which is readily done thus : in the end view O h' is half the thickness, O g' half the breadth of the stub end, and the line n r appears as the point n'; about O describe the arc c' n' with radius O n', then c' will appear in the side view as c on the meridian section, and the arc c' n' will appear as c n, n being directly under c, as in finding any other point of the curve. In the top view the curve g n will be seen in its true form; g will appear at g'', n at n'', and any intermediate point may be found as follows. Taking any point, as s', between g' and c' in the end view, it will appear in the side view on the same level at s between g and c. This point will also describe a circle round A B, an arc of which is s' t', cut at by the second plane. This circle would be seen edgewise in both the other views, appearing as st, s'' t'. Now in the top view t'' will be as far from the centre line as t' is in the end view; so that, drawing s'' t'' under s t, we have only to measure g' t in the end view and make s'' t' equal to it. In like manner we may determine as many points as we please in the top view of this curve, which, like the other one in the side view, may be drawn with the sweeps in the usual way. But it may be remarked that when the cutting plane is, as here shown, tangent to the smaller cylinder—that is, when the thickness of the stub-end is equal to the diameter of the neck of the link, this curve in the top view will usually be so nearly an arc of a circle passing through s'' and t', that it is customary to draw it so, and thus save the trouble of finding intermediate points. But when, as in Fig. 20, the diameter of the neck is less than the thickness of the stub-end, it will be best to construct the curve in both views. In the latter case, the curve in the side view, instead of consisting of two intersecting branches, as in Fig. 23, will be continuous, and have a vertical tangent at the point where it crosses the center line. This subject will be treated more at length in subsequent lessons; and the student is advised to practice the drawing of these curves, taking various conditions as to the proportion between the diameters of the two cylinders, the radius of the circular arc by which they are joined, and the distance of the cutting planes from the axis. For, though when the outline and the position of the planes are given, the resulting curves will appear in the finished work if the mechanic follows the drawing, whether they are shown in the drawing itself or not, the latter is not complete without them, and it is sometimes quite important that they should be correctly laid out by the draughtsman.

SPIRITUALISM.

DR. W. B. CARPENTER lately delivered, at the London Institution, the first of two lectures on "Mesmerism, Odylism, Table-turning, and Spiritualism, considered historically and scientifically." Dr. Carpenter said that there is a continuity in the type of these manifestations from the very earliest times, for the mental tendencies to which the belief is due are the same in the most and least cultivated. For instance, we learn from the early Christian and the classical writers of the same period of the extraordinary phenomena produced by "sorcerers," "exorcists," etc., of whom the most notable were Jews or Syrians. Of Simon Magus, of whom there is a slight mention in the Acts, an early Christian writer related that as he was exhibiting in Nero's presence the feat of flying through the air in a fiery chariot, a feat which he was enabled to perform by the aid of demons, the united prayers of Peter and Paul prevailed against him and the demons threw him to the ground. We are called upon to believe that in like manner Mr. Home stepped out of the window of one room into another at a height of 40 ft. or 50 ft. from the ground, or that Mrs. Guppy was transported from Highbury place through the air to a room in Red Lion street, Holborn, where she descended in the midst of twelve persons sitting round a table in dark séance. These notions are not so prevalent now as the others were in Rome, but we find the same ideas cropping up from beneath as it were. To criticize them, it is necessary to have studied the extraordinary dispositions of self-deception and intentional deception which are admitted even by the candid advocates of spiritualist views. It is necessary to be acquainted with the modes in which exposures have been effected. We find ourselves precluded from getting to the bottom of these things as completely as a conjurer's performance, by various peculiarities of condition which are alleged to interpose themselves between inquiry and discovery. Things that will happen in a light room, and so on. The only prepossession which scientific men can allow to operate is one in favor of the observance of the laws of nature. When a table is said to rise of itself and float about beneath the ceiling, we are justified in requiring a degree of proof of such a fact which we should not require if a more ordinary occurrence were alleged. But, Dr. Carpenter said, like other men of science, he holds himself open to the proof of any new force in nature, if only it is given in the satisfactory way in which the proof of galvanism, magnetism, or electricity was made. Science, as Mr. Huxley said, is nothing but, for instance, organized and disciplined common sense, but no one can go into this kind of investigation with any likelihood of arriving at true results who is not prepared with the kind of special knowledge required for it. A chemist has a special knowledge of chemicals, and students in other branches learn the nature of the instruments they deal with. The instruments of which knowledge is required in this investigation are those very delicate instruments the human body and the human mind—things of peculiar susceptibility, of susceptibilities not constant. Medical knowledge in particular, affords important guidance. Baron von Reichenbach published a work on what he called a new force—Odyl. Reichenbach was the first who investigated that series of combination of carbon with hydrogen, a member of which is so useful to us in the form of paraffin. But he had not the same accurate knowledge of the human organization that he had of chemicals; and those persons whom a medical man would at once recognize as hysterical subjects he labeled with the name "sensitives," as readily affected by his odylic force. When Dr. Carpenter was in practice he could easily have pointed to half a dozen persons who could rapidly be brought into a condition in which they would see everything they were told to see, or feel any kind of sensation mentioned to them. Reichenbach's

"sensitives" saw flames in the dark coming from the ends of a magnet. He did not try the experiment with them of asking them if they still saw the flames when he had covertly removed the magnet. But Dr. Braid, of Manchester, had a patient, a well educated man, who, by keeping his gaze fixed, passed into a state of reverie in which he could be played upon. He saw the flames coming from the magnet in the dark on the existence of flames being suggested to him. The magnet was then secretly shut up in a box, but he still saw the flames where they had been before. That was a scientific experiment. Lord Lindsay took Mr. Home into his library and Mr. Home saw flames coming out of a magnet in the corner. There were many ways in which he might have ascertained before that the magnet was there, and the true way to perform the experiment was to have, not a natural magnet, but a bar magnetized at irregular intervals electrically by an operator in another room, so that count being taken of the times when Mr. Home said he saw flames and of the times when the bar was magnetized by the current, it might be seen whether or not they corresponded.

Dr. Carpenter did not for a moment question the reality of mesmeric sleep. He had seen persons under its influence carry on conversation in a dream not remembered after waking. But he said that in mesmerism it has always been a question of fundamental importance whether the mesmeric coma can be induced without the consciousness of the subject that he or she is being acted upon, and he quoted from scientific works a number of interesting stories to prove that the consciousness is necessary. Bertrand being 100 leagues from his patient, influenced her mesmerically by a letter over which he had made passes. He then sent her a letter over which he had made no passes. Nevertheless, she was thrown at once into mesmeric convulsion. The "magnetist" said he had magnetized the paper unconsciously, so he employed a friend to imitate his writing, and again his patient showed mesmeric symptoms. Mesmer, after he quarelled at Vienna with Dr. Hell, came to Paris, where minds were agitated by the strange ferment which, according to all testimony, immediately preceded the Revolution. He obtained remarkable cures from his system, and the Academy investigated his method, but they could find no signs of magnetism in the apparatus he used. When the apparatus was removed the patients not being informed of it, the same results were produced. They were led blindfold past the magnetic tree and experienced nothing. They were told when far away that they were under its boughs and immediately fell into convulsions. Mesmer himself showed an astounding faith in his theory. "Do not bathe in spring water, but in the river," he told his patients, "for the sun has warmed the river." "But may we not warm the spring water?" they suggested. "Nay," replied the master, "the rivers are warmed by the sun and are magnetic, for I magnetized the sun 20 years before."

Dr. Carpenter then gave the history of divination by the oscillations of a ring or bell suspended. In the second or third century of our era conspirators were executed at Rome for foretelling by these means the death of the Emperor. A few years ago a homœopathic doctor in Brighton and a doctor in London employed it to distinguish between globules. But the results were found to be difficult and to differ according to the theories of the diviner. The divining rod is another superstition of long standing. It is carried in the hands in a constrained position, and where it dips there is a spring of water or a mineral deposit. One remarkable instance of success in this way is that of a French engineer. An engineer might have a very good guess as to where water was. A friend in America recently sent Dr. Carpenter a paper he had written on thought-reading or muscle-reading, and discussing whether one mind can act upon another without any muscular action. His friend related the story of a clergyman noted for his skill in divining the presence of water, who, however, on being blindfolded, did not succeed in finding a spring which he detected when his host, who knew of its existence, was showing him with his eyes open over the premises. The grandfather of the present Sir Charles Dilke himself told Dr. Carpenter of a young man sent to him with an introduction from Portugal, who honestly believed in his own power of finding metals when hidden, but who was entirely baffled when Mr. Dilke buried a quantity of plate in a ploughed field. Dr. Carpenter concluded by remarking that clairvoyance, on which he should have something to say, was the link between mesmerism and "spiritualism," and that far from it being the fact that scientific men had not investigated these things, they had been investigated over and over again. But the results did not become known to the general public, not being usually the subject of legal proceedings; and scientific men becoming tired of making the same inquiry over and over again, some people were convinced there was "something in it." Now, that something was the extraordinary readiness to pursue the marvellous on the part of those for whom the marvels of science are not enough. The history of the spectroscope, and of the radiometer, had shown that scientific men are not at all unwilling to recognize new forces or new manifestations to force, and surely their evidence was more important than the abnormal manifestations of diseased minds.—*English Mechanic.*

CAN "PORT-WINE MARKS" ON THE FACE BE CURED? YES.

By BALMANNO SQUIRE, M.D., Surgeon of the British Hospital for Diseases of the Skin, London.

FEW lesions of the skin are more hideously disfiguring than the congenital "port-wine mark" of the face. I refer to the flat vascular nævus which may so often be met with in every country, causing the greater part (often) of one side of the face to present a livid, dark crimson color, and conferring an almost demoniacal appearance of the unfortunate subject of this forbidding deformity. So many adults of all classes of society may be seen going about with this lesion in its pristine condition, that it is clear at once that nothing is commonly contrived for its relief, and a little experience suffices to prove that any attempt at interference with this deformity is commonly regarded by the profession with disfavor. By some, the possibly uncontrollable hemorrhage is the fear entertained; by others, the scar that would ensue from the only means that seems to be free from the objection cited—cauterization—is properly a reason for refraining. However, as I have satisfactorily ascertained, the disfigurement can be removed without leaving any trace of its former existence, or of the means employed for its removal, and that by a very simple, safe, painless, speedy, and easy procedure.

For the purpose in view I employ a cataract needle, the head of which is about four times the size of the ordinary cataract needle. With this needle I scarify the affected skin making cleanly cut and parallel incisions over the affected area, and even also a little beyond it. The incisions are spaced apart one sixteenth of an inch. In order to render

the operation painless, and at the same time prevent any flow of blood interfering with the draughtsmanship of the lines, I first freeze the skin thoroughly by means of Dr. Richardson's æther spray apparatus. Having performed the operation over a limited area, I press on the scarified portion of skin with the fingers for about ten minutes, gently but firmly. At the end of this time all bleeding has definitely ceased. During the pressure a piece of white blotting paper is interposed between the fingers and the skin. The only styptic I employ is that of pressure employed as that above described. As to the depths of the incisions, they should be made of such depth as nearly to divide the entire thickness of the cutis vera. Within a fortnight, if deftly performed, the operation has done its work without leaving trace of any kind save a notable and most gratifying improvement. No scars are left by it. However, a precaution needs to be stated. No lateral traction must be made on the scarified skin either during or within half an hour after the performance of the operation. In exercising styptic pressure after the operation, this essential precaution must be kept in view. When, in any case, any traction has been accidentally made on the skin in a direction transverse to the direction of the cuts, they gape slightly in consequence. The gaping cuts become plugged with wedged shaped clots, and, as an invariable fact, indelible linear scars are thus produced. If traction be avoided, no trace is left of the operation. Sometimes one operation alone will not suffice, a second or even a third may be required. In such cases the direction followed by the linear incisions of the first operation should be carefully remembered, and at the second operation the parallel linear cuts should be made to cross obliquely the direction of the original cuts, say at an angle of forty-five degrees. If a third operation be needed, the cuts should again follow a different direction, that is to say, they should cross the direction of the original cuts at right angles.

After the operation any exudition of clot or scab should be washed off carefully the next day by a soft camel's hair brush and cold soap and water, followed by a soft piece of sponge wet with cold water only.

The operation conducted as above is absolutely painless. Very slight temporary swelling follows it. No permanent trace is left by it. It does its work finally within a fortnight. No hemorrhage accompanies it, nor is it attended by risk of any kind. It offers to a number of hideously deformed persons an escape from their misfortune which may be safely recommended, and confidently offered by any practitioner. The results obtained by it are at once gratifying to the practitioner and satisfactory to the patient.

DISEASES GERMINATED IN HOSPITALS.

SEVERAL observers have remarked on the presence of globules of pus and microscopic algæ in the air and on the walls of hospitals. Some interesting facts of this order have recently been communicated to the French Société de Biologie, by M. Nepveu of the laboratory of La Pitié. A square metre of the wall of a surgery ward, having been washed, after two years without washing, the liquid pressed from the sponge (about 30 gr.) was examined immediately after. It was somewhat dark throughout and contained micrococcus in very great quantity (fifty to sixty in the field of the microscope), some micro-bacteria, a small number of epithelial cells, a few globules of pus, some red globules, and lastly, a few irregular dark masses and ovoid bodies of unknown nature. The experiment was made with all necessary precautions; the sponge employed was new, and carefully washed in water that was newly distilled. Facts like those referred to make it easy to comprehend how the germs of a large number of diseases occur in the air of hospitals, and how the latter may readily become centers of infection. The same conditions, though in less degree, may sometimes be met with in private life.—*Nature.*

THE CAUSES OF STONE.

THE *Doctor* states that Dr. Debout D'Estrees, medical instructor of the waters of Contrexéville, presented a memoir of the Académie de Médecine on the causes of stone, of which the following are the conclusions:

Gravel formed in the kidney can comport itself in different ways.

1. It may pass from the kidney into the bladder, determining pains more or less acute, and most frequently a nephritic colic, which, according to the nature of the concretion, presents the following variations: Uric acid gravel gives rise to pains, often so atrocious that the patient can scarcely localize them; it is the same with the oxalic acid gravel, but in this case hæmaturia is the rule, whilst it is the exception with the former. The duration of the colic is generally some hours. On the contrary, renal phosphatic gravel gives rise to crises which last often several days; the pain, although severe, is bearable, is localized to the kidney, and there is no hæmaturia.

2. Gravel develops in the kidney, and in the most favorable case does not give rise to any appreciable symptom during life; but most frequently it excites an eliminatory process which causes its expulsion externally in the lumbar region, into the abdomen, and then rupture of the tumor is followed rapidly by death; this tumor, formed by the distended kidney, contracts adherences with the intestine, and the expulsion of the gravel is accomplished per anum.

3. Renal gravel lodged in the ureter may remain there, and give rise to accidents which are always grave. They vary according as the canal is more or less completely obstructed.

4. Gravel arrived in the bladder becomes, if not expelled, the nucleus of a calculus which increases in bulk, either by the addition of elements of the same nature, or by the deposit around it of other salts of urine, and in particular phosphates. This deposit will take place when catarrh of the bladder exists, accompanied with ammoniacal fermentation of urine; or when the abuse of energetic alkalies (bicarbonate of soda, carbonate of lithia, Vichy or Vals water), rendering the urine alkaline, permits the normal phosphates of the urine to precipitate. The unusual termination of calculi, which has received the name of "spontaneous fragmentation of stones in the bladder," occurs either by splitting or exfoliation.

REMEDY FOR PALPITATION OF THE HEART.

DR. J. LARDIES (*L'Union Med.—Clinic*), describes a method by which palpitation of the heart not due to organic lesions may be arrested at once. The patient is directed to bend the body, head down, and the arms hanging so as to momentarily cause congestion of the upper part of the body. In all cases of nervous or anæmic palpitations of the heart quickly resumes its normal functions. If respiration be arrested for a few seconds while the patient is in the above position, the relief is still more speedy.

TREATMENT OF TYPHOID FEVER.

AT a meeting of the *Association Française pour l'avancement des Sciences*, M. Duboué, of Pau, stated that he had treated a number of cases of typhoid fever with ergot, and that his success has been satisfactory. The toleration of ergot increases with the severity of the disease. As a rule, the drug is not so well tolerated by women as by men; consequently, it must be given in smaller doses to the former. It may be given without fear to pregnant women. The pulverized ergot of rye preserves all its medicinal qualities for about eight days; if it lose its physiological properties within that time, it is already altered when pulverized. Of fifteen cases treated by Dr. Duboué, the extreme rapidity of the cure rendered the diagnosis of two uncertain; five cases of moderate gravity that recovered presented during their courses alternations of aggravation and amelioration that corresponded with intentional interruptions of the treatment. Of eight very grave cases, six recovered; three of these cases being already far advanced before the ergot treatment was begun. In the two fatal cases the ergot did not produce its ordinary therapeutic effects, and on examination it was found to be worm-eaten and covered with a grayish powder.—*Gazette Hebdom. de Méd. et de Chir.*

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NOTES OF PRACTICE AND PECULIARITIES OF TREATMENT.

G. M. EDEBOHLS, M.D., House Physician.

THE COLD BATH IN THE TREATMENT OF TYPHOID FEVER.

IN patients possessing the average physical strength, and sick with typhoid fever, the cold bath is employed promptly whenever the temperature of the body rises above 103½° F. The patient is immersed to the neck in water having a temperature of 85°–90° F., and cold water is then steadily added until a bath having a temperature of from 58° to 60° F. is obtained. After remaining in the bath from ten to twenty minutes, the patient is removed, rubbed dry, enveloped in a blanket, and put in bed, and an ounce of brandy administered to aid in establishing reaction. The thermometer is used fifteen minutes after the patient has been placed in bed, and the temperature in the rectum in the male, and in the vagina in the female, has, as a rule, been found to have been reduced from 2½°–4° F.

If at any time during the employment of the bath, symptoms of marked prostration supervene—as evidenced by decided chilliness, lividity of the surface, most readily detected on the prolabia and nails, chattering of teeth, etc.—the patient is immediately taken out of the water, rubbed dry, and warmly covered in bed.

A patient was seen in whom the disease had run its full course twice since his admission to hospital. In the second attack, which was of unusual severity, the cold bath was administered forty-six times in the course of thirteen successive days. The man at the time of the visit was considered as convalescent.

The character of the eruption had been found to be a pretty safe guide with reference to endurance of the baths in any given case. As a rule, when the eruption has been abundant, and of a deep-red color, the reaction after the use of the bath has not been what was desirable, and a few trials has been sufficient to convince the attendants that it was necessary to have recourse to some other form of antipyretic treatment.

QUININE IN TYPHOID FEVER.

In conjunction with the cold bath, quinine might or might not be administered. When, for any reason, cold water is contra-indicated, chief reliance has been placed upon the antipyretic influence of quinine. The drug has been used in the following manner: *First*, It has been given in small doses frequently repeated (5 grains every two or three hours). *Second*, Twenty or thirty grains have been administered in one or two doses at the time when the temperature was highest, generally late in the afternoon. *Third*, The same quantity has been administered in one or two doses when the temperature had about reached its lowest point.

Of these three methods, the first had exercised but little influence in controlling the temperature; the second had generally yielded tangible results, in so far as the temperature, taken from 1 to 3 hours after the administration of the drug, had generally been found to have been more or less reduced; but the improvement was only transient, and another large dose was soon required. The third method was considered the most judicious, and was the one generally employed. The temperature in cases of typhoid fever has been taken every three hours, in the rectum in males, and in the vagina in females; and the average of the twenty-four hours, in patients treated by the third method, has been found to be lower than that of the cases in which quinine was administered in accordance with the first two.

IODINE IN TYPHOID FEVER.

Iodine has usurped the place of the mineral acids, and is given internally in all cases of typhoid fever. It is thought to lessen the troublesome gastric irritability so often present, and to diminish the number of evacuations from the bowels. The following formula is usually employed:

B. Iodinii .... ℥ j.
Potassii iodidi................... ℥ ij.
Aq. dest .... ℥ x.

M. Gtts. iij. in wineglassful of water every three hours.

Lugol's solution, the liquor iodinii comp. of the Pharmacopœia, may be used in doses of six drops every three hours.

The cold bath, quinine and iodine, with the close attention to the diet and the exhibition of stimulants when indicated, constitute the main features in the treatment of typhoid fever. The cold wet pack is occasionally substituted for the cold bath when the latter is not well borne.

ENLARGEMENT OF THE SPLEEN.

Enlargement of the spleen, demonstrated by percussion, has been present as early as the latter part of the first week in all the cases of typhoid fever treated at this hospital during the last two years. Notice was made of this fact, not on account of its supposed singularity, but for the purpose of directing attention to its value in a diagnostic point of view. The enlargement of the organ, it was claimed, could in most cases be ascertained before the appearance of the eruption, and was almost invariably present at the period of the disease when patients generally apply for admission to hospital. When great tympanites exists the spleen may be crowded out of its normal position, and it must then be searched for posteriorly, where it will usually be found lying against the ribs and the side of the vertebral column.

CHRONIC BRONCHITIS WITH EMPHYSEMA.

It has become a sort of routine treatment for cases of chronic bronchitis with emphysema, to administer from one-third to one-half a grain of apomorphia daily, and continue it for some time. It has been given by the mouth, and continued for two or three weeks without annoyance to the stomach. It was believed that the patients did better with than without it, although other medicines were at the same time administered.

INJECTION OF PULMONARY CAVITIES.

In several cases, a hypodermic needle had been thrust through the chest-walls, and into cavities in the lungs, and a few drops of a one and one-half or two per centum solution of carbolic acid injected. *No bad effects have been produced*, and it had seemed to lessen the expectoration and cough, and thus modified the fever.—*Medical Record.*

CLINICAL STUDY OF DIPHTHERIA.

AT the late session of the *N. Y. State Medical Society*, Dr. Bayles read a paper on the above subject, in which he endeavored to prove that diphtheria is primarily a constitutional disease, and that it is in all probability autochthonous and not excited by a specific germ poison. His observations were based on twenty cases of the disease met with in dispensary practice. In all these cases he found that there had been a deterioration of the health and strength for a varying period before the appearance of the disease, and after the commencement of the disease, all, with perhaps one exception, were seen before the appearance of membrane in the throat, and many even before the appearance of the catarrhal throat symptoms. The symptoms these cases presented were, quick, irritable pulse, high temperature, cool extremities without redness of skin, pallor, rather slow respiration, nausea, and sometimes vomiting, diarrhœa, somnolency, irritable temper, and scanty urine of high specific gravity and loaded with urates. In each of these cases the doctor made a slight abrasion of the cutaneous surface at some distance from the usual seat of local lesion, and in every case after a short interval a membranous patch covered the surface of the wound. In one case this was done to verify the diagnosis after the throat lesions had appeared, but in all the others the traumatic exudative patches preceded or appeared simultaneously with the faucial patches or the nasal flux. The appearance of those patches on the body is a certain diagnostic sign of diphtheria, and the fact that they preceded the formation of faucial patches in some cases, demonstrates beyond question the primarily constitutional nature of the disease.

With regard to the etiology of the disease, Dr. Bayles is convinced by his observations that the disease is autochthonous, and neither depends upon nor is propagated by a specific contagion received from without. A predisposing cause is to be found in the noxious influence of bad air, bad food, and uncleanliness, acting on an already impaired and badly sustained system. The fact that many persons in a family often suffer in turn from the disease does not militate against this theory, for all the members of the family are generally exposed to the same noxious influences. The infrequency, not contiguity, and slow multiplication of Dr. Bayles' cases, excluded the idea of an epidemic, and in no case could he, on the closest scrutiny, find one sufficient local cause for the disease.

All of Dr. Bayles' cases recovered, a result which he seems inclined to attribute to the early and active constitutional treatment to which they were subjected. As soon as the diagnosis was made, he gave a single dose of from ten to thirty grains of calomel as a sedative and alterative. The dose for infants was smaller. Two hours after this he gave a powder containing one grain of quinine and three grains of Dover's powder, and repeated it every hour until free diaphoresis was produced, and then at intervals of two or three hours, for twelve hours longer. This was to supplement the action of the calomel, and, at the same time, support. He then gave the elixir iodo-bromide calcium compound, in doses of a teaspoonful every two or three hours until convalescence was established. This medicine he considers as a valuable general tonic and alterative. When possible, he used the same medicine mixed with water as a spray or gargle, but employed no other local treatment. Milk was the chief food allowed, with the addition of a little brandy from the third day. Lastly, the body was bathed two or three times a day with a tepid lotion of salicylic acid, partly as a concession to the disinfectionists.—*Virginia Medical Monthly.*

LESION OF THE CEREBELLUM.

IN a fatal case of diabetes mellitus, which was treated in Mosler's clinic, and in which there had been no disturbances of sensation, or motion, or of the special senses during life, the autopsy revealed a well-marked spot of inflammatory softening about the size of a pigeon's egg, in the nucleus dentatus of the left hemisphere of the cerebellum. The theory of the neuropathic origin of diabetes rests on sound practical grounds, and there can be little reason for doubting that in this case the increased secretion of sugar was excited by the central affection, especially as Eckhard has shown that injury of the second lobe of the vermis cerebelli in rabbits will artificially excite diabetes. It is strange that such a well-marked lesion was not attended by any signs of disease of the central nervous system during life.—*Berliner klin. Wochenschrift.*

LISTER'S SYSTEM AS USED AT FREIBURG.

Dr. A. W. C. BERNS furnishes a summary of the results of the Lister treatment of wounds as obtained in the Freiburg clinique, under Prof. Czerny. In April, 1874, they adopted this treatment. In 1873, there were 901 cases treated, with forty-five deaths, of which nine were from pyæmia and three from erysipelas. In 1874, 910 cases and forty-two deaths, of which pyæmia claimed five and erysipelas three. In 1875, 864 cases and twenty-four deaths, three from pyæmia and one from erysipelas. Conservative surgical procedures have been notably benefited by the employment of this method.—*Archiv. f. klin. Chirurg.*

PHYSICAL SOCIETY—LONDON, DECEMBER, 1876.

PROF. G. C. FOSTER, President, in the chair.

PLANETS BETWEEN MERCURY AND THE SUN.

M. JANSSEN made a brief communication, in French, with reference to a method which he has proposed to the Académie des Sciences for ascertaining whether planets really exist between Mercury and the Sun. After mentioning the importance of photography from an astronomical point of view, he explained his reasons for hoping that a series of solar photographs, taken regularly at intervals of about two hours, at a number of places on the earth's surface, would enable us to determine this question, which is now agitating the scientific world, since any spots which crossed the sun's disc would be at once registered. As it is necessary that such observations be made at several places, and in several countries, M. Janssen hopes that other countries besides France will ere long arrange to have such a series of observations taken, and he considers that in a few years the circumsolar regions would thus be explored with a certainty which could not possibly be attained by any other method. He exhibited some of the original photographs taken in Japan of the transit of Venus, and explained the advantage of placing a grating in the focus of the camera in order to eliminate distortion.

GALLIUM.

Mr. Crookes showed the spectrum of a small specimen of chloride of gallium, which he had received from its discoverer, M. Lecocq de Boisbaudran. The discovery of this metal is of peculiar interest, as M. Mendeleeff had previously, from theoretical considerations, asserted it to exist, and had also correctly given some of its chemical and physical properties. The most prominent line in the spectrum was a bright line in the blue, somewhat more refrangible than that of indium.

FLOW OF ELECTRICITY.

Mr. Lodge briefly described a model which he has designed to illustrate flow of electricity, &c., which is fully explained in a paper in the *Philosophical Magazine* for November, and he showed how similar considerations can be applied in the cases of thermo-electric currents. The model in its simplest form consists of an endless cord passing over four pulleys, and on one side of the square thus formed it passes through a series of buttons held in their positions by rigid rods or elastic strings, according as they represent layers of a conducting or non-conducting substance. When considered in connection with thermo-electricity, the buttons are assumed to oscillate on the cord, and if they move in one direction with greater velocity than in the other, the cord will tend to move in the former direction. Now, at a junction of copper and iron, since the metals have different atomic weights, and their kinetic energies are equal, the velocities must differ on each side of the junction, and an unsymmetrical oscillation of the molecules must ensue, analogous to that assumed by Mr. Stoney to take place in Crookes' radiometer, and the cord, or electric current, will advance when two junctions are at different temperatures. Mr. Lodge showed experimentally that for a given difference of temperature the maximum thermo-electric current is obtained when one of the junctions is at 280° C, and beyond this point the amount of deflection decreases. This fact led Sir W. Thomson to discover the convection of heat by electricity; that is, if we have a circuit composed of copper and iron, and one of the junctions be at the above temperature, the current in passing from hot to cold in the iron, or from cold to hot in the copper, absorbs heat. This fact was experimentally illustrated by Mr. Lodge. A strip of tin plate is symmetrically bent, so as to nearly touch the two faces of a thermopile, and is heated at the bend by steam passing through a brass tube on one side (not end) of the thermopile, and kept cold by a current of water on the other side. As the arrangement is symmetrical, no current is found to pass through the thermopile, but when a powerful voltaic current passes through the strip of metal, a distinct deflection of the needle is observed in accordance with the above law.

MAGNETIC CAPACITY.

By MM. TREVE AND DURASSIER.

LET a horse-shoe magnet, of any length, be covered on one face with a varnish, or, better, a plate of glass. If on the neutral part we place a cylinder of soft iron, we shall see this move towards the poles, which it will reach in a time which is, naturally, a function of the weight of the cylinder, and the coercitive force of the magnet. The magnetic attraction, then, is here exerted not merely in the limited field which has been assigned to it, but over the whole extent of the magnet.

Thus we have a new way of estimating the magnetic force by the *mechanical* work it does. The product of the weight of the movable body by the space passed through, divided by the time, will be the exact measure of this magnetic force. If we determine this force, *e. g.*, for three large and three small magnets, similar in form and weight, and containing respectively 0·250, 0·500, and 1 per cent. of carbon, we can see how it may perhaps be possible to determine the unit of magnetic force, the "*magnetic*," and to fix its equivalence in kilogrammetres.

We have made great efforts to determine the magnetic conductivity of steels in relation to their proportion of carbon; but the want of a *rigorous mode* of estimation of magnetic forces has always stopped us. The phenomenon described will fill the gap, and help us to reach the desired end. We will, however, indicate here the plan we have followed.

If we take *e. g.*, a steel A_1, with 1 per cent. of carbon, of our first Creusot series, its coercitive force is found approximately 47° with the compass. We now enclose it in coils, like an ordinary electro-magnet, giving the coils the proportions of length, section, wire, &c., established by M. du Moncel for obtaining maximum magnetic force; and pass a very strong current. The magnet no longer gives 47°, but 64°. If 47 and 64 were absolute numbers, we might say that the magnet A_1 has 47 of permanent magnetism, but can take 64 in the temporary state. 64 would represent the *magnetic capacity* of the magnet with 1 per cent., that is, the *maximum of magnetism* it can receive. The difference between 64 and 47 would give the magnetic conductivity.

Take now E_1, the extreme steel of the series, with 0·250 per cent. of carbon. Its coercitive force is 13. If we adapt to it the same coils as to A_1, since they are identical in form and weight, we get 69 for the magnetic capacity. The difference between 69 and 13 will be the magnetic conductivity of steel with 0·250 per cent. of carbon.

We have operated in the same way with B_1, C_1, and D_1, and have obtained the following table:

	Coercitive force.	Magnetic capacity.
A_1	47	64
B_1	45	66
C_1	42·5	67
D_1	33·5	68
E_1	13	69

The magnetic capacity of a soft piece of iron, the same in form and weight, was 71. These *approximate* relations show the importance of finding a mode of rigorous measurement of the magnetic force.—*Comptes Rendus.*